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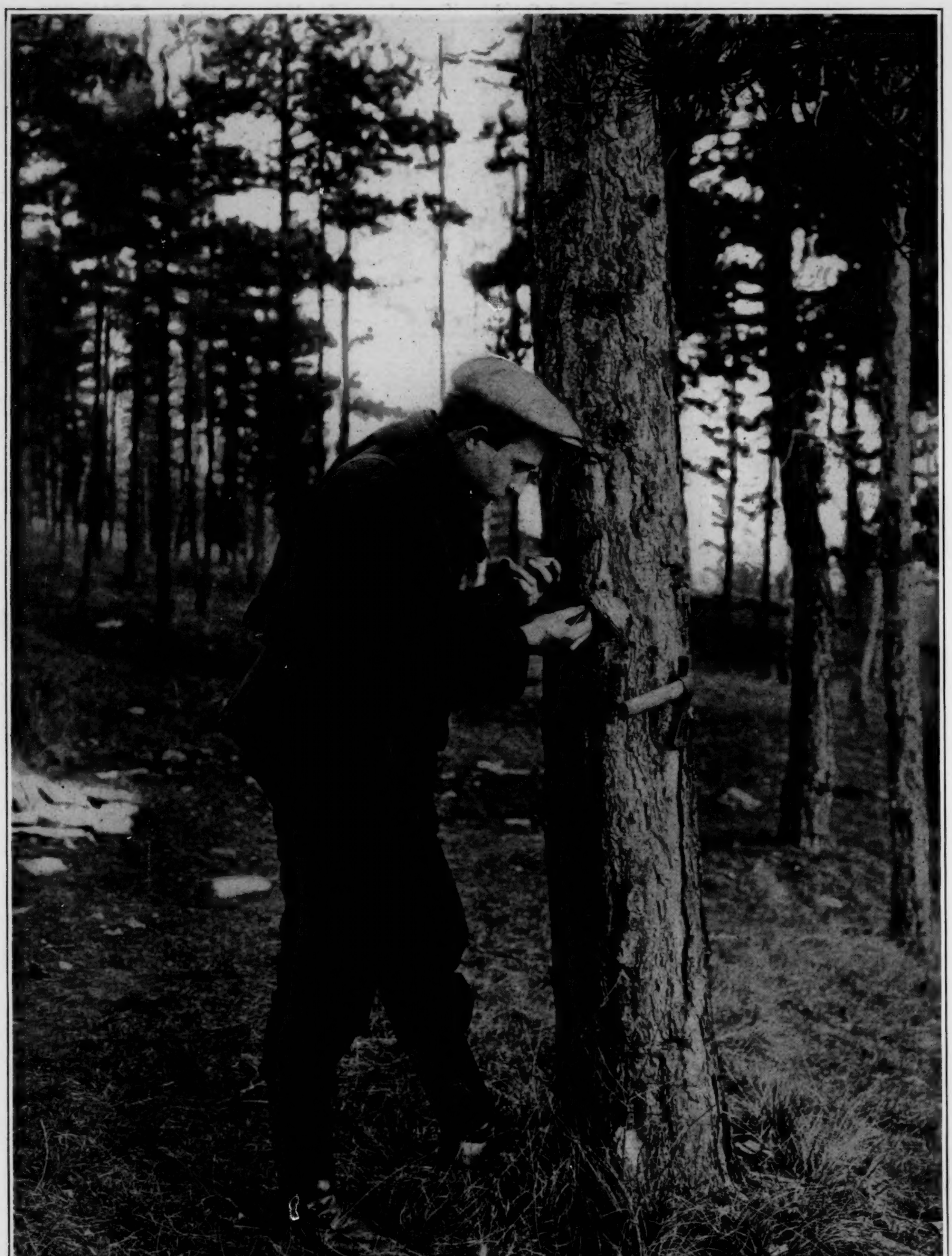

INSECT FOES OF BOOKS—SEARCHING FOR XYLOPHAGOUS OR WOOD-EATING INSECTS. THESE EXHIBIT AN "ACQUIRED" TASTE FOR BOOKS (SEE PAGE 496)

SCIENTIFIC AMERICAN MONTHLY

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MODERN VIEWS ON DEVELOPMENT OF CHILDREN.

JUST as children in former ages of the world were dressed like their parents so that they presented small replicas of the former, so it was supposed that they resembled them in body and mind except so far as the matter of size was concerned. Modern investigations, however, have proved quite definitely that there are very marked differences between children and their elders, both in brain and in body and in those organs of the senses by means of which physiological impressions become psychological sensations. It is worth while, therefore at this season of commencements to consider these things in relation to schools.

We are indebted to an article appearing in the Supplement of the *Chemiker-Zeitung* (Berlin) for some interesting data on recent researches in this field.

It is not generally known that the composition of the chemical elements required by the child's body is very different from that required by older persons and the younger the child the greater this difference is. Thus, a new-born infant's body contains 74.7 per cent of water while an adult's contains only 58.5 per cent. Again the bones of the former are softer because they contain less mineral substance.

In the course of the child's development the heart becomes 12 to 13 times as large as at first, the liver eleven times, the lungs nearly 20 times, and the brain 4 times as large.

Quite as striking is the change in the comparative percentage of the mineral salts in the body of a growing child. In the case of the cartilage, for example, the proportion is 2.24 per cent at 6 months of age, 3.00 per cent at 3 years, and 7.29 per cent at the age of 19. These figures make it sufficiently obvious why ease and grace of movement should be attained by dancing, climbing, running and other physical exercises in early youth, and why on the other hand the greatest care should be taken to prevent the strains attendant upon heavy lifting and the possibilities of curvature of the spine and other deformities consequent upon a too long continuance in a given position or action. These considerations are enough to emphasize the danger of factory work for children.

Even in the composition of the blood there is a marked difference—that of the child containing such a large percentage of white blood corpuscles, or leucocytes, that should the blood of an adult contain the same proportion he would be regarded as seriously anæmic.

But in nothing is the difference between youth and maturity more marked than in the manifold alterations which occur in the bones of the skull during adolescence, and clearly this is a matter of prime importance with regard to a wise plan of education. Not only is the size of the skull in relation to the height of the invidual different in the child, but there is a difference as concerns the relation between the height and breadth of the skull itself. In a new-born infant the skull is comparatively large, its length being one-fourth that of the entire height. At 2 years of age this proportion has decreased to 1/5, at six to 1/6, at 15 to 1/7, and at 25 to 1/8. Again the skull is at least as broad as it is long in the new-born child at its point of greatest width whereas in the adult the breadth equals only 3/4 of the length. The size and form of the separate bones of the skull vary considerably at different ages during childhood and in consequence of this the relative position of the features undergoes variation. Thus at birth the nostrils are placed only a short distance below the socket of the eye, but as the infant develops this distance gradually increases.

When first born the infant is practically blind and deaf. In the infant the Eustachian tube lies in a nearly horizontal position, while it bends abruptly downward in the adult. For this reason inflammation of the nasal passages and the throat much more readily affect the middle ear in the child. There are marked differences, too, in the formation of the tongue and of the larynx, and naturally these are closely concerned with the development of the powers of speech.

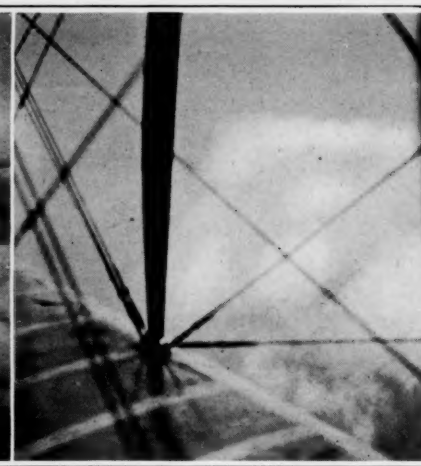
Peculiarly remarkable in children is the large size of the thymus gland, which is almost as large at birth as the left side of the lungs. This gland continues to increase in size till about the third year, remains practically stationary till the beginning of puberty and then disappears. It apparently exerts a definite influence upon the metabolism of early childhood.

We cannot here go into all the variations which occur in the vital organs during growth, but it is worth while mentioning that during childhood the heart is comparatively small with respect to the height of the body, while the arterial system is highly developed. When puberty arrives these proportions are gradually reversed. As a result of these conditions the blood pressure of a child is lower than that of an adult, except in the lungs, where it is higher because the lung artery in a child has a greater diameter than the main artery. This causes a more rapid breathing and a greater liberation of CO_2. This explains the greater activity of the child and the cruelty and folly of requiring it to maintain the same position for hours at a time.

Particular attention is due, too, to the differences in the spine, which is broader and shorter in the child than in the adult. It is extremely soft and flexible, too, hence the danger of curvature, which is sometimes induced merely by carrying a heavy load of books always on one side.

Enough has been said, we believe, to show that the faculty of every school, whether public or private, should include at least one member who has a definite knowledge of juvenile anatomy at every period of growth.

SAN DIEGO BAY PHOTOGRAPHED FROM AN ELEVATION OF 3,000 FEET ABOVE POINT LOMA



CRESTS OF CIRRO-CUMULUS CLOUDS FROM AN ELEVATION OF 6,550 FEET

Photographing Clouds from an Airplane*

Journey Through "The Landscape of the Sky"

By Ford A. Carpenter

Manager of the Department of Meteorology and Aeronautics of the Los Angeles Chamber of Commerce

BEING out of kodak films the writer dropped down from a ten-thousand-foot altitude, requisitioned a Ford from the transport officer at Rockwell field and crossed the causeway to Coronado. Sauntering into the cool and spacious lobby of the Hotel del Coronado he asked the clerk the way to the photograph department. The clerk recognized him as the former Weather Man at San Diego and greeted him heartily. "Won't you stay and have dinner with us?" "No," I replied, "I promised Frank Miller, Master of the Inn at Riverside, when I lunched there this afternoon, to dine with him on my return this evening." As I turned to buy the kodak films one of the flannel-clad, bored-looking individuals who had heard the conversation detained me with "Beg your pardon, but did I hear correctly? That you had lunched this afternoon at Riverside, and expect to dine there at six o'clock tonight?" "Sure," I replied, "I left the Mission Inn shortly after one o'clock, motored to March field, took a JN-4 and having used up the last of my kodak films dropped down here to get some more." "No, I am not an aviator—just a plain, ordinary citizen out on a cloud photographing trip." The flannel-clad individual flipped the ash from his cigarette, turned to his interested companion and ejaculated: "Here's where my ten-thousand-dollar Rolls-Royce goes into the discard."

To my mind this incident illustrates the early superseding of the automobile by the airplane by people who want to accomplish a journey quickly and comfortably. All air-lanes are direct and smooth, although in rare cases perhaps a trifle billowy. While the aviator should be competent to "stunt" in an emergency it should be no more the rule to practice acrobatics in the air than for the ordinary touring car to emulate a daredevil auto racer.

The three-hundred mile cross-country flight of last July was made for the purpose of photographing the higher variety of summer clouds and studying them at close range. Incidentally it was to extend further our studies into differing air levels, continuing this work begun in June. Most of my investigation into air levels of southern California has been accomplished by means of free balloons during a dozen or more flights during all hours of the day and night.

Recognizing the importance of aerial mapping and cloud studies from aloft, the Director of Air Service kindly placed a two-seater and an experienced pilot, Lieut. H. E. Queen, at my disposal for the afternoon. I decided to make the triangular course from Riverside to San Diego and along the coast from San Diego to Los Angeles and thence to the place of starting. The accompanying photographs with their notes were all made by the writer while in the air. Following out a custom inaugurated early in 1911, when air work was first begun by him, a five-minute log was kept. The importance of making one's notes and sketches at regular intervals *at the time* cannot be too highly recommended. I believe that most of the errors of observation are those which creep into notes made afterwards, and, doubtless, are unintentionally colored by the imagination.

NOTE BOOK ENTRIES.

Note book of airplane flight of July 17, 1919, shows the following summary:

March Field to San Diego and return via Los Angeles:

Flight		Mins.	Miles
	Ar DeMille Field 5:27 P. M.		
	Ar Rockwell Field 2:21 P. M.	76	90
No. 2	Lv Rockwell Field 3:39 P. M.		
	Ar DeMille Field 5:27 P. M.	108	130
No. 3	Lv Rockwell Field 6:02 P. M.		
	Ar March Field 6:57 P. M.	55	60
Totals		239	280

OBSERVATION OF CLOUDS.

To the aviator, clouds are a sure guide to the weather in the different air levels, and too much emphasis cannot be laid upon the importance of a thorough knowledge of cloud structure, cloud movement and the resulting weather conditions. To my mind cloud study should comprise as much as one-half of a course in meteorology.

Previous to the last few hundred years weather forecasting with the least pretense to a scientific basis was founded on no other observations than the character and movement of clouds. And now, at the present stage of the knowledge of meteorology, they still give the most valuable local indication

*Abstracted from *The Ace*, Jan., 1920. Copyright 1919 by the author and the Ace Publishing Co.

LANDING THROUGH VELO CLOUDS ON THE ROCKWELL FIELD

MOUNT SOLEDAD (LA JOLLA) PARTLY COVERED WITH VELO CLOUD

of coming changes in weather conditions. The clouds, by their character, indicate the observer's position and proximity with reference to the low pressure area.

A moment's reflection shows that the true direction, as well as the force of the drift of the earth's atmosphere, as depicted by the clouds, is conclusive as a weather indication only in that it determines the relative position and intensity of the storm center.

"WEATHER" IS UNDER 20,000 FEET.

The layer of cloud covering the earth is relatively very thin. If, for example, we could examine the earth from the moon, we would doubtless see a veil of cloud covering little more than half the surface. At that distance the clouds would have no texture, the earth would appear swathed in an irregular sheet of formless vapor, through which, from time to time, the land and water areas could be seen.

The cloud-cover of the earth is most attenuated; it may be compared to a film, for it is supposed to be less than one eight-hundredth of the earth's diameter in vertical thickness.

The thinness of the earth's atmosphere may be more clearly comprehended if we realiize that the relative thickness of the cloud-layer on an eight-inch terrestrial globe would be about one-hundredth of an inch. Yet it is in this thin belt that clouds form, so that it is seen our weather is produced within limited confines.

It is not often given one to select a day when most varieties of clouds are in evidence. First I thought that there would be insufficient clouds on the day selected, and later, from the threatening aspect of the cumulo-nimbus clouds over the mountains and in the high levels, it seemed as if there might be too many varieties of the sterner sort. Fortune again favored me and we had on this journey practically all of the varieties.

COMPOSITION OF CLOUDS.

Clouds occur whenever the temperature is lower than the saturation-point of the air, so that no matter how light or fleecy they may be, or how dense may be the fog, the cloud-mass shows by its presence that precipitation is taking place. Their height defines their relative density.

Here are the general classifications: Cirrus, cumulus, stratus and nimbus.

Cirrus, the Highest Cloud.—This is of delicate fiber, feathery in structure and pure white in color. It is the most elevated of all clouds, having an average altitude of five miles, and sometimes extending into the lower limit of the so-called isothermal region of the atmosphere. This cloud is doubtless composed of spiculae of ice. A popular name for this cloud is "mare's tails," and it is the wind cloud of the sailors.

Cumulus, the Day Cloud.—The typical summer clouds that thrust their heads up into the air—they are the great conventional clouds. Generally speaking they are thick and dense and their tops are smaller than their bases. As they are caused by ascending currents, their life is dependent upon the duration of the vertical current, so that when the air ceases to rise, the cloud disappears. During the ascent of the sounding balloons at Avalon, Catalina Island, in the summer of 1913, especial care had to be taken not to let loose the balloons during the proximity of cumulus clouds, as they were the danger signals of strong upward air currents.

Stratus, the Lower Cloud, is a gray, undefined cloud sheet; in fact, any horizontal mass of uniform thickness, independent of height, characterizes this cloud. When it is of low altitude it sometimes becomes the velo cloud. The stratus cloud is of considerable value as an insulator of the sun's rays, and, on the other hand, almost entirely checks the loss of heat by radiation from the earth at night. May and June would be among the hot months in littoral California were it not for the cloud then prevailing. In winter, citrus growers know that there will be no frost if stratus clouds are present, for they serve as a blanket and thus hold the earth's heat.

Nimbus, the Rain Cloud, is, technically, any cloud mass from which precipitation is falling. It always forms under a higher variety of cloud.

MODIFICATION OF CLOUD FORMS.

These four are the general classification of clouds all over the world. A modification of these varieties gives the following modifications:

Cirro-Stratus, which is easily distinguished by the fact that in it are formed the halos. The diffraction of light by this cloud produces rings around the sun and moon, technically known as the solar and lunar halos of 22° and 45° radii.

Cirro-Cumulus forms in semi-transparent balls; it is the mackerel sky cloud that forms suddenly and marks the transitory stage between a higher and a lower variety, or *vice versa.* This cloud was very much in evidence within a quarter of an hour after leaving March Field. It was like sailing from one aerial haystack to another, so well-defined were these round cloudy masses. When this cloud is accompanied by threatening phenomena it is the surest rain indication that we have in southern California.

Alto-Cumulus is composed of small masses of cumulus cloud in parallel rows.

Fracto-Cumulus.—This term is applied to a cumulus cloud when its edges are torn or shredded by the wind.

Alto-Stratus is a high stratus cloud, nearly always thickening into the ordinary low type and becomes a somewhat threatening cloud. This formation causes solar and lunar coronae.

Strato-Cumulus.—Long feathery rolls, which are shallow in winter, and if present in quantities, are a threatening indication. During the spring and summer, they generally disappear without causing precipitation.

Fracto-Stratus is the lowest cloud form, and is therefore only a slight remove from fog tattered by the surface wind.

Cumulo-Nimbus is the "thunderhead," and the most impressive of all cloud forms. When whisps of thundercloud are seen above the towering masses they are called "false cirrus."

Fracto-Nimbus.—Near the level of the sea this is the "scud" of the sailors. Among the higher levels, it sometimes occurs as a trail of cloud dark with moisture stringing after the larger cloud, sometimes dissipating before the lower edges of the veil reach the earth.

The study of the composition of the clouds is quite important if we wish to interpret their meteorological significance correctly. The altering composition of a cloud-mass, whether a higher cloud is changing to a lower variety, or whether a cloud near the earth is dissipating—both processes having a direct bearing on local weather conditions.

FORMATION OF CLOUDS.

Before leaving this subject let us examine into the causes which underlie the structure of cloud.

Minute nuclei make possible formation. Laboratory experiments demonstrate that condensation in air cannot occur unless there is some object on which the condensation can take place, whether it be a material surface, a dust or water particle.

Nuclei are necessary for the formation of a water drop. It is a most important fact that a water drop cannot be formed in the free air unless there first be a nucleus on which the moisture can be deposited. The nuclei may be dust particles or ions. Experiments show that the condensation occurs at a much lower temperature in dust-free air, so that dust particles are by far the more important source of nuclei. As for dust, it must not be supposed that condensation is delayed on account of the absence of dust nuclei, for we have no instance in nature where the air is so pure near the earth that vapor could not form. A beam of light, whether it be from the sun or an artificial source, shows innumerable dust motes in its projection through the air. In fact, we know that light itself is made visible because of the presence of these dust motes. The dustier the air, the greater the diffusion of light. As ionized air permits condensation though dust may be absent, it is probable that the condensation at the higher levels of the atmosphere may be thus caused.

THE SIZE OF A DROP OF WATER.

The size of water drops has been found to average one-thousandth of an inch in diameter. Experiments prove that such a drop falls at the rate of two inches per second. This unusually slow rate led the earlier investigators to believe that droplets were hollow spheres, hence the vesicular theory of rain formation. It has since been discovered that particles of steam or fog are solid globes. Ascending air currents readily suspend such minute and slowly falling particles, often forcing them upward a great distance. In the case of thunder storms, the convectional force is terrific; witness the size of hailstones which owe their size to their being forced upward many times to a great height for their numerous coatings of ice.

Condensation necessary for the formation of clouds may be caused by either convection or contact. Convectional clouds are produced not because the air mass rises into a colder region, but because the mass itself has been dynamically cooled. Cumulus clouds, rain clouds, and rain itself, are due to dynamic cooling.

Another form of convection results from the great whirling eddies of the atmosphere, which are the "lows" of the weather map. Local reduction in atmospheric pressure will also cause ascending currents.

DOWN CURRENTS GIVE FAIR WEATHER, UP CURRENTS RAIN.

Whether or not the currents are ascending or descending may be readily observed by the tips or tufts of the cloud formation. If these feather edges point downward, we know that the winds are descending and therefore becoming warm and dry; if ascending they are becoming cool and moisture-laden. Local ascending currents may be caused by forest or other fires. Spectators of the great San Francisco fire described a towering cumulus cloud which overhung the burning city. When a fierce forest fire occurs on a calm day a small cumulus cloud capping the smoke column is not an unusual sight.

MEASUREMENTS UP TO 108,000 FEET OF ALTITUDE.

In the summer of 1913 cloud investigations were carried on by the aid of free balloons. For example, the balloon soundings at Avalon in July and August of that year revealed some of the innermost secrets of the clouds. The records from the instruments, which soared twenty miles and over, showed that the steady decrease in moisture is uniform, becoming practically nil at the upper limits.

It was also found that the "velo cloud" (a cloud peculiar to the Pacific coast, which will be described later) extends upwards on an average of one-quarter of a mile; that the trade-wind is about two and one-half miles thick; and that the particles composing the highest cirrus clouds are widely separated and are continually forming and re-forming, generally at an elevation exceeding five miles.

THE LIONS OF THE SKY.

The first clouds encountered on this journey were the cumulo-nimbus. In the air it is sometimes difficult to determine whether a towering thunderhead is a cloud or a mist-covered mountain.

At first sight it was somewhat terrifying, for the plane was apparently headed for destruction. But like Bunyan's lions their appearance only was terrifying.

It was observed especially whether the eddying wind movement in the vicinity of these clouds affected the behavior of the ship. It did not. Perhaps it was owing to the skill of the navigator, much as a good sailor will so take advantage of wind and currents as to keep his vessel from either pitching or rolling.

THE SHEEP OF THE SKY.

If the thunderheads are the lions of the sky, then the cirro-cumulus are the peaceful sheep. In regard to the cirro-cumulus my notes say:

"No sight is more exquisite than the cirro-cumulus cloud-flecked air as seen from above."

As these cirro-cumulus clouds became more closely packed it was like sailing from one hill-top of mist to another. We passed through several; some were dense enough to obscure the light, and this part of the journey was like traveling through a very short and quite dark tunnel.

The minutes sped by so rapidly that before I realized it the long low-lying cloud which had been observed skirting the coast resolved itself into our old familiar friend the velo cloud.

THE VELO CLOUD.

This cloud is peculiarly a product of the Pacific coast; of all the delightful memories of San Diego the one that sticks closest is that of this early morning and late evening cloud. The writer described this cloud in a small volume on local climatology[1] from which the following has been condensed:

"EL VELO DE LA LUZ."

The challenge, "We all know the winters are warm in San Diego, therefore the summers must be hot," constitutes the most common misunderstanding of San Diego's cool summers. The fact that there is less than one hour per year above 90

[1]Climate and Weather of San Diego, by Ford A. Carpenter, Mount Pleasant Press, 1913.

CIRRO-STRATUS CLOUDS IN WHICH SOLAR HALOS ARE FORMED

LOOKING DOWN ON A CIRRO-CUMULUS CLOUD

CUMULO-NIMBUS CLOUDS COMMONLY KNOWN AS "THUNDERHEADS"

degrees is not easy to explain, until we remember the old Mexican phrase, El velo de la luz, "The veil that hides the light." This is a folklore expression, originating not only before the Gringo came, but, doubtless, long before the coming of the old Spanish conquistadors. The better-known English term, "high fog," has, in common with most words of our language, a double meaning, and it is misleading to a non-resident.

It is not fog in the generally accepted meaning, for this "light veil" is neither cold nor excessively moisture-laden. Neither is it high, for its altitude is less than a thousand feet.

While the velo cloud is common to the Pacific coast generally, and has been observed as far north as the Straits of Fuca, this cloud reached its perfection over the littoral region of southern California.

The velo cloud is the chief characteristic of the summer climate of the San Diego Bay region. And summer should be understood as covering all the year excepting November, December, January and February. These four months could easily be reckoned as spring-time.

The screening of this region from the sun's rays is so thoroughly accomplished that, during a normal summer's day, the sun breaks through the velo cloud about 10 o'clock, the sky clearing shortly afterwards and remaining free from clouds until about sunset.

That the velo cloud is effective as a sun-shield, it needs only to be stated that the average of all the July maximum weather temperatures since weather observations began shows a mean of about 78 degrees.

The cause of the formation of the celo cloud and, consequently, the cool summers of San Diego is, strange to say, found in the hot weather in the interior of California and Arizona. It is a unique example of the aptness of the proverb, "It's an ill wind that blows nobody good."

The hot weather in the interior produces an aerial eddy (the "low" of the weather map), and the difference in atmospheric pressure between the interior and the ocean results in giving San Diego cool, uniform days and nights, free from extremes, or what is really the summer temperature of the Pacific ocean. The velo cloud should therefore be incorporated in our local vocabulary, and it should replace the misnomer "high fog."

LAKES AS SEEN FROM THE AIR.

One of the most exquisite views from a plane, in my opinion, is a lake or reservoir, and Lake Hodges on the San Dieguito River, which we passed over at nearly eight thousand feet elevation, was no exception to the rule.

Owing to the time of the year the water in this artificial lake was somewhat depleted, leaving a shimmering, white border which formed the edge of the lake.

As Lake Hodges was not on the map it was quite disconcerting to locate our whereabouts, but with the compass I decided that the lake had been created since the map was printed.

This is another example of the usefulness of the airplane in not only showing very clearly the necessity for accurate maps, but filling that want with the aid of a camera.

COLORING FROM THE AIR.

I never cease to marvel, when in either an airplane or in a balloon, at the colors which spread out beneath one. This was especially true in negotiating the air over the beautiful grounds of the thousand-acre park, not long since the scene of the Panama-Pacific Exposition. Owing to the vertical vision there are advantages about airplane and balloon observation totally lacking in any other view.

Someone has compared such a scene to an exquisite Persian rug spread out beneath him. Be that as it may, every field,

every kind of crop, the varying geological formations all stand out with startling clearness. Viewed from above, low trees, brush and other chaparral have a texture of almost inviting downiness. I have often thought that a good colorist could make his fortune if he would paint from a balloon basket or the cockpit of an airplane.

As in all art there is no gain without some loss. Although the colors stand out with great vividness the majesty of the mountains and the beauty of the canyons and the running streams is lost. In my opinion there is still but one way to enjoy nature and that is on foot or on horseback. The airplane is no improvement over the automobile for the enjoyment of scenery.

From Point Loma on until we swung inland near Point Firmin the trip was that of a seaplane. For nearly one hundred miles the plane thundered its way on an even keel four thousand feet above the shimmering sea. Whenever the ship swung towards the shore, even ever so slightly, the differing paths could be readily determined by the contrasting shades. As color values were entrancing when flying over the fields, so also was the sight when skimming the meadows of the sea with its acres and acres of exquisitely colored seaweed. This was especially in evidence as we winged our way over La Jolla with its turquoise bay and paralleled opalescent cliffs of Del Mar. The hum of the motor and the singing of the struts and stays in the hurrying air, together with the even temperature so near the ocean, produced a drowsiness and only the imperative duty of making five-minute notes kept me awake.

A PHYSIOLOGICAL SELF-EXAMINATION.

Seated comfortably and calmly in the protected cockpit I took advantage of the opportunity for a careful self-examination as to the effect of flying on the human system so far as I was personally concerned. I reviewed the pulse tests which I had made at differing elevations; at 10,000 feet or at 2,000 there was not the difference of half a dozen beats. The bodily temperature remained the same at different altitudes. In the sudden drop from 10,000 feet to sea-level at Rockwell Field I noticed pains in the ears which lasted several minutes after landing. There was not at any time the least sensation of dizziness, although being rapidly subject to seasickness or carsickness. I had long wanted to try out whether or not I could hear myself shout in a plane. Removing the helmet I yelled at the top of my voice, but such was the drone of the motor and the hurricane blast of air that even the head-noise could not be distinguished.

WIND EFFECT OF DEBOUCHING CANYONS.

Most pilots state that with a fast plane there is no appreciable effect on traveling past the mouth of canyons debouching into the sea. In order to prove or disprove this the following observations were made. As is well known, the seacoast from Point Loma to Point Firmin is furrowed by deep canyons emptying into the ocean. The speed of the plane was too rapid to permit a view of approaching canyons, so for several minutes at a time I closed my eyes in order that sight might not confuse a preconceived notion, only opening them when the ship lurched. Five observations thus made of slight sideslips were directly traceable to the passing of canyon mouths.

PHOTOGRAPHIC EQUIPMENT.

Perhaps a word as to the photographic equipment used in this journey may not be out of place.

It has long been my feeling that it was the man behind the gun rather than the gun that brought down the game—but that goes without saying. At any rate I think that a man should take with him a camera which he is perfectly familiar with. My own practice is to use a common kodak fitted with a fine astigmat lens and a reliable shutter. A universal direct view finder is essential as are also two kinds of rayfilters. On my first journey, many years ago, I was foolish enough to take a foreground filter! Little did I then realize that there is no foreground in the air! Also, there is no need for focusing. It is necessary to set the scale at 100 feet and the shutter and diaphragm at appropriate values and use the camera as man would a machine-gun.

One precaution is necessary in the air: the film must be rolled up with great deliberation, for quick turning of the spool will cause static in the dry air of these elevations with consequent hair lines and blotches on the film. The film must be handled with extreme care both before and after taking the picture.

INSTRUMENTS USED ON THE TRIP.

Before bringing this narrative to a close it might be worth while to mention some of the instruments used independently of the regulation altimeter, compass, etc. I refer to the photographic and meteorological apparatus.

BAROGRAPH RECORD OF JOURNEY.

Two barographs were taken on this journey, one recording on an open scale up to five thousand feet and the other over a more constricted profile up to fifteen thousand feet. Both instruments gave highly comparable and therefore satisfactory results. Naturally the needle passed off the limits of the sheet on the first instrument, but all of the journey was recorded on the second barograph with five thousand feet to spare.

I found these barographs of very great utility in all journeys whether on foot, horseback, automobile, railroad, balloon or airplane. In fact on all means of travel save by steamboat, these barographs give an automatic record of every moment of the journey.

THE HOMEWARD FLIGHT.

After traversing more than half a hundred miles of air fragrant with orange blossoms we flew over Riverside and dropped into the home field. A few minutes after landing I was on a motorcycle and shortly afterwards passed through the hospitable arches of the Mission Inn. Here was where I had lunched only a few hours before and now the cool and quiet interior and warm and friendly greeting of the Master of the Inn added the finishing touches of anticipation of the waiting dinner.

And thus this air trip was ended ninety miles over the mountains, one hundred and thirty along the sea coast and sixty over the orange and lemon groves. Into these four hours of flying were crowded studies of air currents; photographing of clouds at close range; testing out of some intuitional theories and the intimate observation of land, sea and sky. So much was thus made possible in so little time that to my mind this journey brings out with startling distinctness the one great outstanding fact in flying—the expansion of time. In obeying the scriptural injunction "shall mount up with wings as eagles" the airman takes hold upon divinity for can he not also say with scripture "One day is with the Lord as a thousand years, and a thousand years as one day?"

LUNAR CRATERS.

PHOTOGRAPHS taken from the air of the effect of bomb-dropping on a fairly large scale afford very plausible evidence that the lunar craters are more likely to have been formed by impact than by volcanic action, according to H. E. Ives (*Astrophysical Journal*, Nov., 1919, pp. 245-250). He meets some of the supposed difficulties which have been brought forward in opposition to the bombardment theory: *e.g.*, the absence of similar effects on the earth; the prevalence of the circular shape, and so on, and he replies to the objection that meteors are not explosive bombs, by the argument that the enormous heat generated by a direct collision with the moon's surface, far greater than that which causes fire-balls to explode in our atmosphere without reaching the earth's surface, is more than sufficient to produce all the explosive effect necessary.—*Science Abstracts.*

Did the Babylonian Astronomers Possess Telescopes?*

Their Observations of Venus, Mars, and Saturn

By Dr. Heinrich Hein

THE two planets which stand closest to the sun, Mercury and Venus, when observed through the telescope exhibit a sickle form like that of the moon and for the same reasons. Only one-half of their spherical surface can be illuminated by the sun, and since their orbits are within that of the earth they must necessarily turn towards the earth a larger or smaller portion of their non-illuminated noctural side. Consequently the portion of the illuminated diurnal side of these planets which we are capable of still seeing from the surface of the earth passes through phases like those of the moon. Fig. 1 shows the apparent magnitude and varying form of Venus.

It was in the year 1610 that Galileo first gazed upon Venus with his newly constructed telescope and perceived her sickle-like form. In none of the writings of the ancient Greeks and Romans and in none of the astronomical works of the Arabs is there any indication that anyone before Galileo had ever perceived the sickle form of Venus. It is not until very recently that any uncertainty has been felt as to whether Galileo was really the first discoverer of the phases of Venus. Some years ago, however, the following prophecy was discovered written in cuneiform letters and uttered by some Babylonian astrologer:

"When it cometh to pass that Venus hideth a star with her right horn and when Venus is large and the star is small, then will the King of Elam be strong and mighty, holding sway over the four corners of the earth, and other kings will pay him tribute."

This is then immediately repeated with the exception that the word *right* is replaced by *left* and the name *Elam* by that of *Akkad*. Akkad signifies Babylonia, the arch enemy of Elam, and these two nations were in ancient days (cc. 2,000 B.C.) the only two great powers of Asia Minor, and were engaged in a struggle with each other for the mastery of the world as known to them, i.e., for the rulership over the whole of Asia Minor. The blotting out of a small star by the "horn" of Venus must have been such an extraordinary occurrence as to induce the astrologer to connect with it the greatest prize in his power to offer, dominion over the four corners of the world.

There is absolutely no doubt that the Babylonian word in

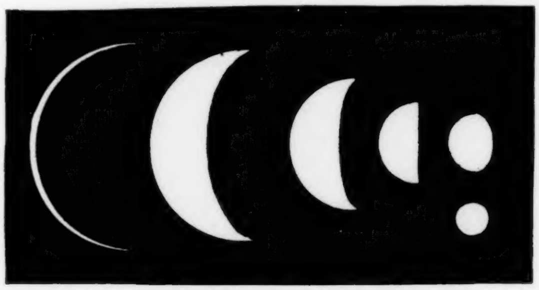


FIG. 1. THE PHASES OF VENUS SHOWING THE CORRECT PROPORTIONAL MAGNITUDES; ABOUT 60": 55": 38": 25": 16": 9".

question signifies horn. Hence it really looks as if the Babylonians had recognized the phases of Venus. But since they had no telescopes they must obviously have perceived the planet's form resembling a sickle with the naked eye. Yet, as we have said, neither the Greeks nor the Romans were ever able to see the horn of Venus although their astronomers studied the planets zealously enough. In the northern part of Europe the evening star was observed very diligently long before Galileo and yet no one ever perceived its phases.

Hence it has been suggested that the Babylonians must have possessed exceptionally favorable conditions. The air is clearer in that region than in Europe—so clear that bodies upon earth are capable of throwing shadows in the light of Venus—so clear indeed that it is possible to recognize Venus with the naked eye even in the light of day; furthermore, the Babylonians are credited with sharp eyes. A certain Assyriologist assures me indeed that some astronomers have

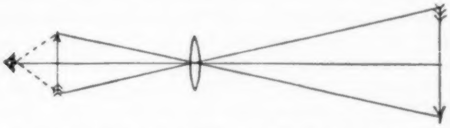


FIG. 2. DIAGRAM OF THE SIMPLE CONVEX LENS EMPLOYED AS A MAGNIFYING GLASS

been capable of observing the phases of Venus with the naked eye in the clear atmosphere of Oriental lands.

The reasons thus advanced for the thesis in question are not all entirely satisfactory. Even in Europe Venus is capable of throwing shadows under specially favorable circumstances; likewise, we too can see Venus by daylight when conditions are such that the planet possesses her greatest degree of brilliance and when the observer knows exactly that point of the heavens in which to look for her. Anyone who has ever sought to locate the brighter fixed stars at the first fall of night knows how difficult it often is to find them at first and how readily they can be found again after they have been once located. Napoleon I once saw Venus in the full light of day upon an occasion when he chanced to cast his eye upon the right spot in the heavens and thereafter counted the planet as his special star of fortune. As for the supposed keen eyesight of the Babylonians it certainly seems peculiar that the Arabian astronomers who searched the heavens very diligently in later centuries under exactly the same conditions, had no knowledge of Venus's changing form.

As for myself I do not consider it impossible to perceive with the naked eye a certain degree of elongation in an object of the size and form of Venus when she possesses her greatest brilliance and at a time when she appears both somewhat larger and somewhat narrower (for Venus does not possess her greatest apparent magnitude at the time of her greatest brilliance). But in such a case such an object could not be so bright as Venus, for the reason that very bright objects appear to illuminate the retina over a much larger circumference than is actually the case—they appear to be enlarged. The arc of an arc light is no larger than a candle flame or a gas flame of the kind formerly used, i.e., without a mantle. From a great distance the arc light appears like a brightly radiant disk, whereas the candle or gas flame at the same distance will appear to be merely a yellow point of light. Similarly it is a well known fact that the brighter fixed stars appear to the human eye larger than those whose light is fainter, in spite of the fact that even in the strongest telescopes none of the fixed stars exhibits a perceptible diameter, but they all resemble mere points.[1] It is the same with Venus. Human beings are found rarely free from such a super-exci-

*Translated for the SCIENTIFIC AMERICAN MONTHLY from *Kosmos* (Stuttgart), February, 1920.

[1]It is true also that the brighter fixed stars appear to the human eye perceptibly greater than those whose light is fainter, although none of the fixed stars exhibit a measurable diameter even in the strongest telescopes, and must therefore be recorded as mere points of light.

tation (irradiation) of the retina. One such individual was the astronomer Heis, who was able to recognize Mercury, Venus, and Jupiter in the bright light of day, and who perceived all the fixed stars as mere points, and who was able to distinguish eleven stars in the Pleiades, while the normal person perceives only six, and some few people can see seven or eight. I have never heard that Heis was able to recognize the phases of Venus, but if he could not do so this would weigh against the theory that the Babylonians were able to do so, as it must likewise weigh against this theory that the Babylonians recognized only seven stars in the Pleiades.

Thus it seems to me highly improbable that the Babylonians were capable of observing the phases of Venus with the naked eye, if not entirely impossible. I have, therefore, pondered the question as to whether the Babylonians did not perhaps possess some sort of magnifying instruments. We know that the ancients were acquainted with hollow mirrors, which were used as "shaving mirrors" are among us, to magnify the face and which were also used in Greece, for example, like burning glasses in order to kindle the sacred sacrificial fire by the light of the sun itself. We are told, too, that somewhat later Archimedes kept the Roman fleet away from the harbor of beleaguered Syracuse by means of powerful "burning glasses." It occurred to me, therefore, that the observation of the phases of Venus must have been made possible to the Babylonians by means of the burning glass or hollow

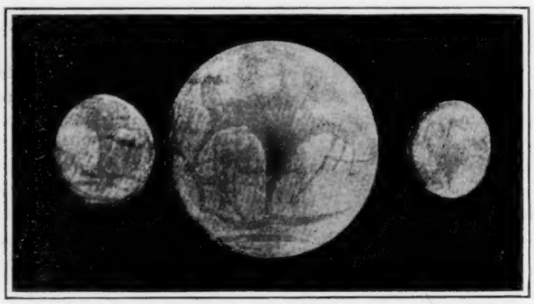


FIG. 3. MARS IS NEAREST TO THE EARTH: 25″. GREATEST PHASES PREVIOUSLY 13″: 11″; SUBSEQUENT PHASES 11″: 9″

mirror. Everyone understands the method by which a burning glass consisting of a convex lens operates. Every one at one time or another has thrown an image of the sun upon his hand with such a glass or burnt a hole in a sheet of paper with it. The distance of the image of the sun from the lens is called the "focal distance" of the lens. At this distance not only an image of the sun is formed but likewise images of all objects which are located at very great distances from the lens. This is readily verified by using a lens at night to experiment with distant sources of light, such as bright windows, lanterns, etc. When the luminous object comes considerably closer to the lens its image recedes from the lens; however, this fact does not here enter into the question.

Let us assume for example that the lens has a focal distance of one meter—this signifies that the lens will form an image of the sun at a distance of one meter from itself. But it is likewise true that an object only 100 meters distant will throw an image at the same distance of one meter (practically speaking), but we must remember that the respective magnitudes of the object and the image bear the same relation to each other as do their distances, i.e., in the instances referred to the object will be 100 times as large as the image. Again the diameter of the sun might be calculated with the same laws. The sun is 150 millions km. distant from the earth. Hence if the sun's image is formed at a distance of one meter this implies that the sun is 150 billion times as far from the lens of the image. Thus we need only measure the diameter of the sun's image in millimeters and multiply it by 150 billions and we shall obtain the diameter of the sun in millimeters.

Suppose that the object situated at a distance of 100 meters is a brightly lighted window 100 centimeters high and observed in the evening. The image will be situated at a distance of 1 meter and will be exactly 1 centimeter high. It can be received upon a pane of ground glass. If we now observe the lighted window from a distance of 100 meters and the image from a distance of 1 meter, it is obvious that both

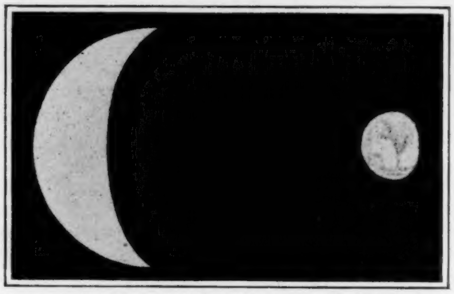


FIG. 4. THE MOST CLEARLY MARKED PHASES OF VENUS AND OF MARS SHOWN IN THEIR CORRECT PROPORTION WITH RESPECT TO MAGNITUDE AND TO BRIGHTNESS: 55″ AND 13″

will appear of the same size to the eye. (Thus from the view point of the lens the object in the image always appears the same size.) If we now desire to see the window appear four times as large we must approach the actual window until we are only 25 meters distant. However, this fourfold enlargement can be obtained more conveniently by observing the image at a distance of 25 centimeters. Then the image will appear four times as great as the object at 100 meters' distance. If the image has been received upon a screen of ground glass, then it can be observed from either side and the eye can approach the image until the required degree of magnification is obtained. If the image be regarded from the rear side of the ground glass screen—in which case the screen stands between the lens and the eye—the screen may be slowly moved forward. We then observe that the image slowly moves down the screen until it finally hovers freely in space at the same point where it was first found upon the screen (see Fig. 2).

The matter may be summed up, therefore, as follows: The object at a distance of 100 meters appears to be of the same size as the image at a distance of 1 meter. Since, however, the eye, is not forced to regard the image at the distance of exactly 1 meter, but can without trouble observe it at a distance of 25 cm. it is possible to obtain with a simple lens

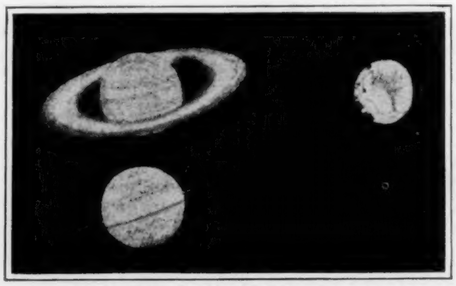


FIG. 5. THE MOST MARKED PHASES OF SATURN AND OF MARS SHOWN IN THEIR CORRECT PROPORTIONS AS TO MAGNITUDE. THE BRIGHTNESS OF MARS EXCEEDS THAT OF SATURN AS MUCH AS THAT OF VENUS DOES THAT OF MARS (FIG. 4). 16″ TIMES 42″ AND 13″

having a focal distance of 1 meter a fourfold enlargement of objects at a great distance. It is my belief that this use of the simple convex lens as a telescope is entirely new, although such lenses have been employed as microscopes for centuries.

Anyone who has a spectacle lens of very slightly convex form can easily construct a one lens telescope for himself. The only thing required is a cardboard tube. The focal dis-

tance of the lens is first determined, which is readily done by using it to form an image of the sun or the moon and then measuring the distance from the lens to the spot at which the said image is most sharply defined. Suppose that the focal distance happens to be 75 centimeters. Twenty-five centimeters is then added to this and the tube is made 100 cm. long. The lens is inserted at the forward end of the tube and the eye is placed at the rear end in order to observe any given object located at a great distance. It will be found that the said object appears as an inverted magnified image. The field of vision is exactly as large as the lens and is, therefore, of no significance. When an ordinary spectacle lens is employed the image is somewhat distorted. The placing of the eye presents the chief difficulty. The best method is to place a diaphragm in the tube at a distance of about 25 cm. from the eye at about the point where the image would be formed. The eye then has an indication as to where it can be probably best placed. Anyone who has a long telescope tube needs only remove the rear lens, but in this case the eye must generally be placed 15 to 20 cm. to the rear since telescope tubes can rarely be extended to so great a length as is here necessary. It is now obvious that with a lens having a focal distance of 10 meters it is possible to obtain a magnification of 40 diameters. The same thing holds true with regard to concave mirrors as to the double convex lens employed above, with the exception that the observer must look within the mirror instead of through it.

It was not until a considerable time after I had come to the conclusion recorded above that I learned that certain Babylonian texts also speak of the horns of Mars. Since the Babylonians were also accustomed to apply the term "horn" to very slight swellings, it is possible that they had reference to the phases of Mars, though these are small (See Fig. 3).

Under the best circumstances we are able to see only about one-sixth of the dark nocturnal side of Mars. But Mars is so very far distant from the earth that it is probably impossible for the naked eye to perceive the disk distorted. Its diameter is hardly 15″, whereas Venus exhibits a diameter of 55″ at the period when the curved sickle form is plainest to be seen (see Fig. 4). Hence it would be probably impossible for the unassisted eye to perceive a slight elongation of the planet. Thus the Babylonian reference to the horns of Mars likewise raises the question as to whether the Babylonians may not have possessed primitive instruments capable of telescopic observations—a question which I believe can be answered in the affirmative, at least as regards the possibility.

However, in spite of this *possibility* I do not believe that the Babylonians really did make use of the concave mirror as a telescope. Such mirrors must be ground in the form of a portion of a whole sphere, or, better still, in parabolic form. Such grinding requires machines, whereas it is certain that the mirrors ground by hand which the Babylonians possessed were of short focal distance and such mirrors produce distorted images. Then, too, if they were able to recognize the phases of Mars they certainly must also have known something about the form of Saturn. The diameter of the latter is about 16″, and the largest diameter of the ring is about 40″. As we know, the ring disappears at times when we are looking straight at its edge. This phenomenon, that Saturn possesses "horns" which it loses at times should not have escaped the observation of the Babylonians and must have intrigued their imagination. In case records of such observations are discovered with respect to Saturn they would certainly furnish testimony in favor of the Babylonian's use of the concave mirror as a telescope.[3] Until such a text is discovered, however, I shall be of opinion that the mention of the "horns" of Venus and of Mars refer to the phenomena of refraction in the air by means of which the former planet is distorted to resemble a narrow line, which might possibly extend to a small fixed star. Such an occurrence would be an exceedingly rare phenomenon, justifying an extraordinary prophecy.

[3]The late M. W. Meyer mentions somewhere the representation of the planet Saturn with rings by the Babylonians. However, the Babylonians sometimes represent other planets also as surrounded by rings. In my opinion only a direct mention of the rings in the cuneiform text would be convincing. And we must recall, too, how difficult the astronomers of the 17th century found it to recognize the true nature of the rings in spite of the possession of comparatively good instruments.

The Origin of Comets*

Do They Form a Part of Our Solar System?

By Elis Strömgren
Director of the Observatory of Copenhagen

The following article is an abstract made by the author himself, the distinguished Danish astronomer, Prof. Strömgren, *of a longer article published in Scientia (Bologna) for August,* 1918.—Editor.

ALL comets known to us have been observed within our own solar system. Our sun is one of billions of suns to whose ensemble the name is given of the Galactic System, and in all probability there are million of systems similar to our own galactic system.

Our little solar system is composed of the sun, of the planets with their satellites, and of comets. It is with the latter that the present article deals and we shall confine ourselves to the study of the following questions:

Whence do comets come and whither do they go? Do they form a part of our own solar system, or are they, as it were, migratory birds coming from afar and folding their wings for but a moment upon the edge of our own little nest in the heavens?

Ever since man has been capable of meditating upon those things which lie beyond his immediate grasp, these questions have exerted a profound attraction upon his imagination. The opinions of astronomers upon this point have long been divided and changing, but today we are in a condition to give a positive answer to the question as to the origin of comets.

The law of gravitation is the basis of all calculations relating to the orbits of the celestial bodies, and if this law were unknown to us it would be impossible to conceive of a discussion of the problem of celestial movements. We are all familiar with the method by which the effect of this force upon two celestial bodies—the sun and the earth, for example—can be demonstrated. The small body, *i. e.*, the earth, is forced to describe an elliptical orbit about the larger body, *i. e.* the sun. Such is the orbit of the earth and such also are the orbits of the other planets.

However, the mathematical study of the problem shows, as every one knows, that the problem of two bodies comprises the possibility of two other kinds of orbits, namely the parabola and the hyperbola. As we know, the ellipse consists of a closed curve while the parabola and the hyperbola are open curves whose branches are of infinite extent.

As a result of this an elliptical orbit in the case of a comet indicates that the comet belongs to our own solar system, while an orbit, which is either parabolic or hyperbolic indicates that

*Translated for the *Scientific American Monthly* from *L'Astronomie* (Paris), for October, 1919.

the comet comes from outside our system, in other words, from interstellar space. Thus the question of the origin of comets appears to be very simple: if we collect in a single table all the orbits of comets which have been thus far calculated we shall find that a certain number of them form ellipses while others are either hyperbolas or parabolas. From this the conclusion may be drawn that some comets belong to our solar system while others come from outside. Yes! the problem *appears*, indeed, to be very simple, and it is in this simple manner that astronomers treated it until about twenty years ago. But the matter is in reality far more complex, as we shall presently see.

* * * * * *

In speaking of the "problem of the two bodies," and of the explanation of the orbits of planets and of comets, we have intentionally neglected a point which is of very great importance with respect to the making of *exact* calculations. We know how the attraction of the sun causes a planet such as the *earth*, for example, to describe an ellipse around the sun. We can also prove in the same manner that the planet Mars describes a similar orbit around the Sun. But in reality besides the attractions which are exerted between the Sun and the Earth and between the Sun and Mars there is a mutual attraction between the *Earth* and *Mars*, and in spite of its relative insignificance this force deranges the motion of the two planets, which would otherwise be purely elliptical. These small derangements in the elliptical movements of celestial bodies are termed *perturbations*.

The calculations of the *perturbations* undergone by the movements of the planets has formed the principal problem of theoretic astronomy for the last two centuries. But this brings us to an important point in the problem of comets.

The orbit of a comet which has been calculated by the aid of observations of the said comet cannot be looked upon as valid, in fact, except for a certain period of time, namely, that period during which the comet has been observed, *i. e.* while it was in the vicinity of its perihelium, for the easily understood reason that the comet is not visible from the earth at a point beyond a certain distance from the perihelium, either while approaching or while departing. It is in this manner, *i. e.* by the aid of a very small portion of the orbit that orbit after orbit has been calculated. In the course of time a table has been obtained which contains several hundred orbits of comets, and this table has formed the basis of all the conclusions which have been drawn concerning the origin of comets.

No one had ever raised the question as to whether the most interior portion of the cometary orbit is really a true expression of the manner in which the comet entered *originally* into the interior portions of our solar system. It is only some twenty years ago that the following very simple questions occurred to anyone: Have not the large planets of our solar system exerted an appreciable influence upon the orbits of comets during the long period of time which has been required by them to enter the internal portion of our solar system? And is it not possible that this influence might be great enough to change an orbit which was originally elliptical into a hyperbolic orbit and vice versa? And if this be true must not the problem of the origin of comets be reconsidered?

Let us consider the matter more nearly. Among the various qualities which characterize an ellipse a parabola or a hyperbola there is one which is particularly important with respect to our present problem. It is that which might be called the *degree of elongation*. Astronomers and mathematicians call this the *eccentricity* of the orbit and designate it by the letter E.

In order to state the matter clearly let us set down the following figures:

1. A circle has no elongation. Hence we say that its eccentricity E equals 0.
2. In an ellipse E may have all the value comprised between 0 and 1.
3. In the parabola E equals 1.
4. In the hyperbola E is greater than 1.

If we have calculated the orbit of a comet, therefore, by the aid of our observations and have obtained as a result: $E = 0.999,500$, this signifies that the orbit is elliptical and if we have obtained as a result: $E = 1.000,500$ this means that the orbit is hyperbolical.

But among the numerous orbits which have been calculated there are as a matter of fact a great many cases in which the eccentricities are found to be in the vicinity of unity, the majority being a little bit less than 1 while the others are a little bit more than 1. And we know by the foregoing observations the fundamental difference which exists, from the point of view of cosmogony, between those cometary orbits in which the eccentricity is a little less than 1 and those in which it is a little more than 1. In the first case the comet must belong to our solar system, while in the other case it must have come from outside.

But let us now return to our original point of departure: The orbit which has been calculated by means of our observation, *i. e.* by the aid of its most interior portion, cannot be exactly the same as the orbit possessed by the comet in those portions which are exterior to our solar system. It is necessary therefore to calculate the perturbation. It is necessary to see what was the degree of eccentricity of the orbit when the comet was far away from us. Such researches have been carried on during the past twenty-two years and the results to which they have led can be summed up in the following manner:

If one follows for a sufficient length of time the different comets in their passage towards the exterior one finds that not a single hyperbola remains. The cometary orbits which were hyperbolic in the internal portion of the solar system acquired this hyperbolic form by reason of the perturbations to which they were subjected by the planets.

Here then we have the answer to our questions regarding the origin of comets: *Comets belong to our own solar system*, and whereas in former times astronomers believed themselves obliged to distinguish between *periodic* comets and *non-periodic* comets, we speak today only of comets which have *short periods* and those which have *long periods*.

* * * * * *

Various arguments have been proffered in contradiction of this theory that comets belong to our solar system. Various authorities have attempted to discover, by the aid of statistical methods, systematic peculiarities in the movements of comets. For example, the question has been debated as to whether the planes of cometary orbits in space are grouped in a special manner—or whether there are special points in the heavens whence comets appear to come by preference and it has been suggested that such peculiarities in the movement of comets might show that comets enter our system from outside it.

But as for the first point it has been demonstrated by Holetschek that a multitude of such peculiarities in the movements of planets are only *apparent*—for they can be explained by means of conditions which inhere in the observations which have been made with regard to the Earth; furthermore, all things considered, we are not able to imagine any systematic peculiarities belonging to the orbits of comets which cannot be explained by the theory that comets form a part of our solar system. Even if, for example, we are able to demonstrate that comets come principally from particular areas of the sky it is quite useless to suppose that they have departed from certain locations in space external to our system in order to enter this system. The fact is explained quite as well by the highly probable supposition that in distant localities *situated within our nebulous regions* there formerly existed concentrations of nebular matter which latter gravitated toward the center. Hence the existence of such systematic peculiarities in the movements of comets cannot prevail against the positive proof which we have here given that comets belong to our own solar system.

LAST OF THE ONCE FAMOUS "MOUND CITY" THREE MILES NORTH OF CHILLICOTHE, OHIO

Remains of the Mound Builders in the Scioto Valley

Curious Earthworks That Are Being Destroyed by the Ravages of Civilization

By R. W. French

WITHIN the confines of the State of Ohio and notably in Ross County along the valley of the Scioto River and its tributaries were at one time numerous remains of the Mound Builders, or Indian Mound Builders, so styled from the nature of their remains; while today few remain, even some of the largest having disappeared before the plow, village and city of a modern people and civilization. At one time a few minutes' travel in almost any portion of this great valley brought the visitor to one of these more or less interesting remains, either mound or fortification, while today it often takes quite a little traveling to find one or two that have sensibly escaped the ravages of modern man.

Chillicothe, county seat of Ross County, was once the scene of several Indian villages and within the corporate limits of that town there were no less than ten mounds and six enclosures, or earthworks, the work of a bygone and little known people; today only two of the mounds and none of the earth-works are discernible and one of the remaining mounds is fast disappearing to supply earth for fills where desired.

A mile and a half to the north of Chillicothe was the so-called "Mound City," the exploration of which supplied much of the information obtained regarding the people who left these interesting remains for the study of the archaeologist. The first explorers of this group reported that there were no less than 24 mounds within the enclosing earthwork. Today this area, which is a portion of Camp Sherman, U. S. Army cantonment, is practically devoid of any vestige of mound or enclosure. One mound remains within the cantonment and this was outside of the enclosure.

The remains of the Mound Builders are found on both the high and low ground, but the more extensive works and larger mounds, as a whole, occupy the flat land in the valleys; all of which accounts for their early decadence before the plow of the farmer. In certain instances, such as Fort Hill, Spruce Hill and Fort Ancient, hill tops were enclosed, apparently for the purpose of defense, and to afford places of refuge in case of attack. Many of the higher eminences are crowned by small mounds generally supposed to have served for signal fires with which information was passed from village to village, rather than as tumuli, such as the larger mounds in the valleys are generally found to be.

These lesser mounds have escaped destruction generally, their sites not being arable and being more or less heavily wooded. These works are often so small as to be hardly recognizable as such, a close survey of the hilltop being necessary to determine the artificiality of the crest.

Of the more important groups, one known as the "Hopewell Group," about four miles west of Chillicothe on the North Fork of Paint Creek is today a well cultivated field and few of the original twenty-six mounds reported by the first explorers remain other than as slight rises in the ground, many

LARGE MOUND HALF A MILE SOUTHWEST OF BAINBRIDGE. ITS SIZE CAN BE JUDGED BY COMPARISON WITH THE FIGURES IN THE FOREGROUND

MOUND ON THE FAIR GROUNDS AT CHILLICOTHE. THE LARGE LOCUST NEARLY 3½ FEET THROUGH AT THE BUTT GIVES SOME IDEA OF THE AGE OF THIS EARTHWORK

THE SEIP OR PRICER MOUND NEAR BAINBRIDGE ON THE BANKS OF PAINT CREEK

SMALL MOUND NEAR CHILLICOTHE THAT IS STILL IN A GOOD STATE OF PRESERVATION

years' cultivation serving effectually to cut them down. This is likewise true of the earthwork formerly enclosing these mounds.

This group supplied a great deal of information to archaeologists, many implements, both stone and copper, as well as a number of skeletons being recovered in the excavation of these mounds. From one mound more than eight thousand flint disks were removed. These disks were found in pockets of twelve or fifteen each with a layer of sand between each pocket. The weight of this cache was more than three tons.

Twelve miles southwest of Chillicothe, near Bainbridge, Ohio, there are several well preserved mounds. One of these, known as the Seip or Pricer mound from the name of the people on whose land it stands, has not been opened; the owners refusing permission for its exploration. At one time there were several other mounds in the immediate vicinity, but today no remains are noticeable.

Between Chillicothe and Bainbridge on Paint Creek is the hill-top fortification of Spruce Hill. The work overlooks the hills along the Scioto River to the east of Chillicothe as well as many miles to the north and south of its site. The hill has steep, in some cases almost precipitous, sides; and is a spur projecting from a table land to the south. The enclosure is formed by a wall of stone which closely follows that margin of the nearly level summit. The material for the wall was procured near at hand from several rock outcroppings which are common to this part of the state. The wall is continuous except for several breaks to the south, where it crosses the table land. These breaks were apparently left for gateways.

The remains of this wall is badly overgrown by timber, but its site is easily traceable by the many stones scattered about. At no place are the stones in a semblance of a wall, though the scattered stones cover the ground to a thickness of several feet; judging from the amount of material on the ground and the steepness of the slope it should have been easy to defend the area against invasion by hurling stones or other missiles on the heads of the attackers. This wall is said to enclose the largest area in the world enclosed with a wall entirely constructed of stone.

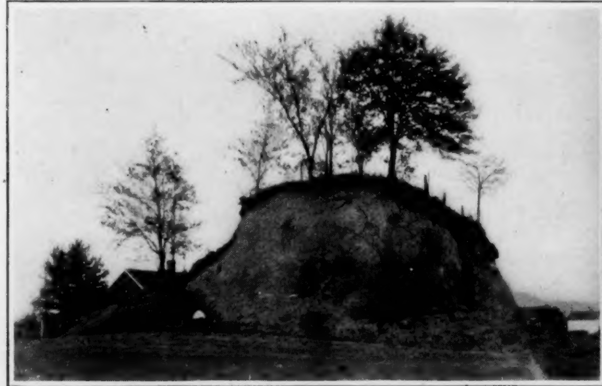
Of the remains in the proximity of Chillicothe, no doubt the most famous is the Serpent Effigy Mound, 40 miles to the southwest in Adams County. This is one of the most striking effigy mounds known and a visitor is impressed of the artificiality of this remains at the first view. Over all the mound is more than 1,300 feet long and depicts a serpent of several convolutions, jaws extended and an oval within the grasp of the huge jaws.

This effigy is situated on a precipitous point of land near the junction of the east and west forks of Brush Creek; and skirting Brush Creek is so precipitous as to prevent scaling from that direction, while from the opposite side the ascent is fairly gradual.

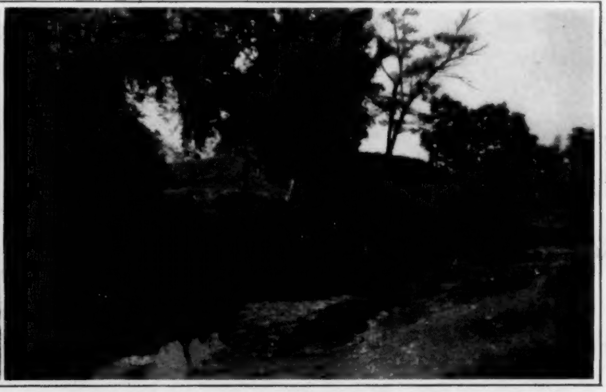
On coming up the slope the visitor sees the tail commencing with a small terminal pit. Following the earthwork, which is from two to four feet in height and from three or four feet to 20 feet in thickness, we follow the unfolding coil for two full turns, then advance along the body which gradually increases in height and width with three large folds and ending in the extended jaws and lastly the oval earthwork, detached from the body proper.

The meaning of this earthwork has caused not a little speculation among students of archaeology and even today with the study of several remains that have been unearthed from time to time its purpose is not definitely settled. Within the oval an altar of stones was discovered and remains of cremations and copper ornaments. This, however, has only served to increase the several arguments regarding the reasons for the effigy, which is so striking, and which is in no way duplicated anywhere in this region of the United States.

The antiquity of the mounds is not known. Some Indian legends have it that they were in existence at the time of the Indian and that they were then heavily overgrown with trees



MOUND THAT HAS BEEN CUT TO SUPPLY DIRT FOR FILLS, SHOWING HOMOGENEOUS NATURE OF MATERIAL COMPOSING IT



MOUND ON LICK RUN, FOUR MILES SOUTHEAST OF CHILLICOTHE, WELL PRESERVED BECAUSE THE LAND IT OCCUPIES IS NOT ARABLE

VIEW OF THE SERPENT EFFIGY MOUND, SHOWING THE THREE BROAD FOLDS OF THE BODY AND IN THE DISTANCE THE OVAL WITHIN THE EXTENDED JAWS

NEAR VIEW OF THE SERPENT EFFIGY MOUND, SHOWING THE SIZE OF THE EARTH WORK. IT IS 1,300 FEET OVER ALL, 20 FEET WIDE AND 2 TO 4 FEET IN HEIGHT.

which would make them very old within the time of the Indian. Other legend has it that the Mound Builders were a race distinct from the Indian and that the latter overcame them and destroyed them. Other claims presented are that they are a branch of the Aztecs of Mexico or other races of the Southwest.

However, an analysis of the remains fails to confirm or disprove any of these assertions beyond a shadow of doubt. In many respects the remains show no connection between the civilization of the mound builder and that of Europeans, tending to show that the works are pre-Columbian, while at the same time, in many ways there is no material difference between the works found in the tumuli to cause any great distinction between the work of these people and the Indians. Both stone and copper implements have been unearthed in considerable quantity, but in nearly all instances work of the same type and nature is connected with known work of the later Indian races.

The copper is thought to have been obtained from the large deposits in the Lake Superior region, as those mines show evidence of having been worked by aborigines many years ago. If this is true, a considerable traffic was no doubt developed by these people. That, though, can be accounted for largely by migratory trips in the summer to the copper regions, or by exchange between various tribes; the latter no doubt the more probable, inasmuch as barter is a well-known trait of the early American.

Of written history, hieroglyphics or pictures, practically none remain, and of the remains none have any tendency to dispel the general gloom regarding the history and civilization of the mound builder. With the rapid destruction of the remains and the fact that early exploration was not carried on in the systematic manner pursued by the archaeologist today it seems little likely that the question of antiquity and origin of this race will be deciphered. Furthermore people that are interested in seeing these remains in situ will have to make haste as time and the ravages of modern civilization are fast removing the last vestiges—where there were thousands of mounds and earthworks yesterday, there are barely hundreds today.

FIGHTING GRASSHOPPERS WITH FLAME PROJECTORS

THE agricultural regions in the southern part of France suffered considerably from the grasshopper plague during 1918 and especially in 1919, when the *Dociostaurus marocanus* insects multiplied to an extreme degree. Other districts in France suffered from the *Calliptamus italicus*, while the northern part of Africa was invaded by the *Schistocerca tatarica*. The French Government recently sent three official expeditions to these regions, one to Morocco and two others to the south-east of France in order to investigate the nature of these insects and their depredations, and especially to find out the best means for their extermination. A prominent agronomist, P. Vayssière, was actively engaged in this class of work, and we are indebted to him for the present account of the various researches which were made during the year 1919, especially in the great plains region of the Crau. The Department of Agriculture in fact proposed to make use of different destructive methods or products which had been brought out during the war. The tests included in the first place the use of flame projectors devised according to army practice. Heavy coal oil is the fuel employed, and the apparatus is found to give remarkable results against swarms of grasshoppers either at rest or moving along the ground. Insects touched by the flame or stationed on an area of about 3 feet around the burned surface are instantly killed. With one filling of the apparatus of some 12 liters' capacity, a surface of over 200 square meters can be treated. It is preferable to use two or three apparatus in line, so as to cover a zone of 100 square meters in a very short time. The second method consists in the use of toxic gases which suffocate the insects, and the experiments bore upon two such gases; one was a mixture of oxychloride of carbon and chloride of tin, which was considered during the war as highly poisonous to man and animals, but it did not seem to act to any extent upon the numerous swarms of grasshoppers, even though they underwent the action of very concentrated gas at distances from 0.10 to 4.0 meters from the outlet. On the contrary, excellent results were obtained with an atomizer spray of chloropicrine in aqueous emulsion at 25 or better at 50 per cent. When touched by the sprayed drops, the insects in all cases died within a few seconds. This compound does not appear to burn the vegetation to any great extent, as it is seen to flourish again in a few weeks. Further investigation is in order upon this subject in the south of France. The author also made use of bait in the shape of arsenical salts made up with bran, using only 0.5 kg. of arseniate of soda for 12 kg. of bran, and this was hand-sowed on meadow land covered with grasshoppers. Twelve hours afterward, it was found that great numbers were poisoned, and within 48 hours about 80 per cent were destroyed. He covered over 500 square meters of ground in this case. As a result of all these tests, it is considered that the grasshopper plague can be fought very effectively, especially when we have to do with swarms of young larvæ. The three methods can best be employed as follows: Flame projectors upon all ground where there is no danger of fire; atomizers with spray using highly concentrated solution of chloropicrine in all cases where flames would prove dangerous; arsenical bait upon irrigated prairie land where animals do not pasture.

Insect Foes of Books

The Bookworm Past and Present

WHAT *is* a bookworm? In other words what image rises in the reader's mind when he hears the word? Very probably the picture flashed upon his mental screen is that of some bespectacled Doctor Dry-as-Dust Dominie Sampson poring diligently over learned volumes. But such a picture is obviously one derived from a secondary meaning of the word. What then is a *real* bookworm? How big is it? What is its shape? What is its nature? What are its colors, and what are its habits, aside from its predatory predilection for books? Doubtless nearly everyone who reads these lines has a pretty clear mental image of an earthworm, a silkworm, a "measuring worm," a tobacco worm, a cabbage worm, etc., etc., but how many are capable of describing a bookworm?

WHAT BOOKWORMS REALLY ARE.

To begin with, it must be remarked that bookworms are not really worms at all in the scientific sense of the word "worm"; they are something quite different according to the best authorities, being really insects of various sorts, either in the adult state or in the larval state. In the latter stage of life, i.e., as larvæ, they do, of course, much resemble true worms to the non-informed.

The truth is that the word bookworm has been very loosely applied for many centuries to any sort of living organism, living in or preying upon books. The first mention, perhaps, of the bookworm is in a passage from Aristotle, which reads as follows: "In old wax, as in wood, there is found an animal which seems to be the smallest of all creatures, called acarus. It is small and white, and in *books* there are others like those found in cloth, and they are like scorpions without a tail, the smallest of all." This insect has been plausibly identified with the *acarus cheyletus* of the order *acaridae* which is described by F. J. X. O'Conor, of the College of St. Francis Xavier, New York, as being "extremely small, hardly visible to the naked eye, pink in color, and corresponding perfectly to Aristotle's description." This authority, however, thinks it highly unlikely that this minute creature does any real damage to books, though often found in them.

But why should insects of any kind haunt books at all, and when and why did they acquire this taste? These questions are easily answered, for no matter how barren of intellectual wealth a book may be, and how unattractive to the human bookworm, it is a rich storehouse of varied food for such creatures as are capable of assimilating the cellulose of its paper, the wood and leather of its binding, or the gluten and starch of the paste that binds its pages together. Hence the wood-eating (Xylophagus) insects which live on the wood of trees as well as the ordinary cockroach and "water-bug" which feeds on starch and gluten, and all those insects which, like white ants, are capable of feeding on cellulose, find in a book a well-stocked larder and in a library mountains of provisions such as Joseph heaped up for the Egyptians in the seven fat years of plenty, that came before the seven lean years of famine.

Among the commonest of the insects known as bookworms are the larvæ of the Coleoptera or sheath-winged beetles. Seven varieties of these have been found in books in this country by F. J. X. O'Conor:

1. *Sitodrepa panicea*, larva.
2. *Attagenus pellio*, larva.
3. *Sitodrepa panicea*, full-grown insect.
4. *Lepisma saccharina*.
5. *Ptinus fur*.
6. *Dermestes lardarius*.
7. *Anthrenus varius*, larva.

Sitodrepa panicea, larva.—"The most voracious of these beetles is the *Sitodrepa panicea*, of which I have examined," says Mr. O'Conor, "thirty specimens. Here in New York I have found it as well as in Washington. In the larva form it is a soft, white six-legged worm covered with bristles. It is about ⅛ of an inch long and moves very slowly."

This little creature is worth a lengthier description since it is not only voracious but practically omnivorous. In Europe it is still known as the bread beetle from its occurrence in dry bread, but it by no means confines itself to bread and books. In this country it is commonly known as the drug store beetle, since it plays havoc with the pharmacist's supplies. The division of Entymology in the United States Department of Agriculture some years ago honored this active depredator with a special bulletin, to which we are indebted for the following description of its aspect and habits:

This beetle is a member of the family Ptinidae. It is cylindrical in form, measuring about a tenth of an inch in length, and is of a uniform light-brown color, with very fine silky pubescence. The elytra are distinctly striated and the antennæ end in an elongated three-jointed club. When at rest the head is retracted into the peculiar hoodlike thorax and with the legs and antennæ folded under and tightly appressed to the body, the little creature easily escapes observation. The larva is white, with darker mouth, and of a cylindrical curved form. The pupa is white.

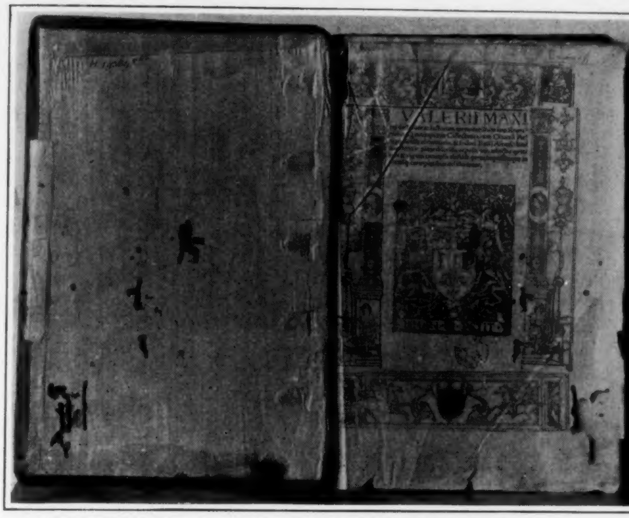
It invades stores of all kinds, mills, granaries, and tobacco warehouses. Of household wares its preference is for flour, meal, breakfast foods, and condiments. It is especially partial to red pepper, and is often found in ginger, rhubarb, chamomile, boneset, and other roots and herbs that were kept in the farmhouse in our grandmothers' day. It also sometimes gets into dried beans and peas, chocolate, black pepper, powdered coffee, licorice, peppermint, almonds, and seeds of every description.

The subject of injuries wrought by this species has formed the text of a considerable literature going back to the year 1721, when Pastor Frisch found the larva feeding upon rye bread, and including, besides damage of the nature referred to, injury to drawings and paintings, manuscripts, and books. Some singular instances are recorded of the injury it does as a bookworm. The late Dr. Hagen wrote that he once saw a whole shelf of theological books, two hundred years old, traveled through transversely by the larva of this insect, and still another record is published of injury by the species *Ptinus fur* to twenty-seven folio volumes, which it is said were perforated in a straight line by one and the same insect, and so regular was the tunnel that a string could be passed through the whole length of it and the entire set of books lifted up at once.

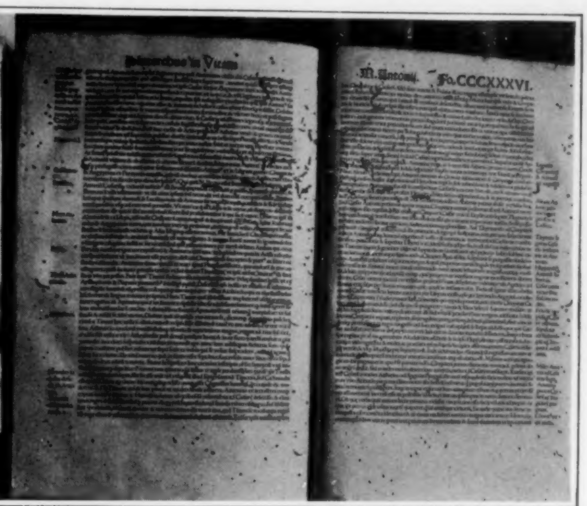
In pharmacies it runs nearly the whole gamut of everything kept in store, from insipid gluten wafers to such acrid substances as wormwood, from the aromatic cardamon and anise to the deadly aconite and belladonna. It is particularly abundant in roots, such as orris and flag, and sometimes infests cantharides (Spanish flies).

It is recorded to have established a colony in a human skeleton which had been dried with the ligaments left on, and the writer has seen specimens taken from a mummy. It has even been said to perforate tinfoil and sheet lead, and that it will eat anything except cast iron. In short, a whole chapter could be devoted to the food materials of this insect, as nothing seems to come amiss to it and its voracious larvæ. The subject may be concluded with the statement that this division has received complaints from four different correspondents, of injury to gun wadding, and there are several records of injury to boots and shoes and sheet cork.

The larvæ bore into hard substances like roots, tunneling them in every direction, and feed also upon the powder which



TUNNELS BORED IN OLD BOOK BY THE DERMESTES, KNOWN IN FRANCE AS THE "GIMLET" FROM THE REGULARITY OF THE HOLES IT MAKES



PAGES OF AN OLD BOOK IN THE BIBLIOTHEQUE DE L'ARSENAL, RIDDLED BY THE BOOK-EATING LARVAE OF VARIOUS INSECTS

soon forms and is cast out of their burrows. In powdery substances the larvæ form little round balls or cells, which become cocoons, in which they undergo transformation to pupæ and then to the adult insect. I have reared the insect from egg to beetle in two months, and as it habitually lives in artificially heated buildings and breeds all through the winter months, there may be at least four broods in a moderately warm atmosphere.

In France the *sitodrepa panicea* is known as the *anobium paniceum*, and the great French authority Houlbert, the author of *Les Insectes Ennemis des Livres*, a book which won one of the prizes offered at the International Congress of Librarians held in Paris in 1900, declares that in France nine-tenths of the injury done to books proceeds from this unpleasant pest. It is not generally known that the sound made by this insect, which resembles the monotonous ticking of a time-piece, has earned for it from the superstitious the name of the Death watch. The well-known French entymologist, the Abbé Plessis, gives an entertaining account of the death watch which should rather be called the Love watch, since the sound is really the mating call of the insect. He says: "One day one of my pupils brought me an anobium which I placed for a few days in a light box on my tab'e. It occurred to me to knock upon the table with my penholder and the insect promptly answered me. At the end of a few days, when it had become accustomed to its surroundings, I took it out of the box and placed it upon my table where I and many others observed this curious action. This insect is gifted with a singular elasticity between the head and thorax. It makes its knocking sound by bending its head entirely underneath the thorax and then knocking with the top of its head."

The *anobium tessellatum* and the *A. Pertinax* are likewise guilty of depredations. Because of the extreme regularity of the tunnels bored by these insects in wood or in books, they are commonly called "gimlets" in France. Their presence in a room can be detected by small heaps of a reddish powder, lying upon shelves or furniture or on the floor. Where such *dejecta* is observed means of extermination should promptly be applied.

The *anobium hirtum* is found occasionally in the center and south of France though not in England. It is more common in the southern part of the United States, large numbers having been found in the State Library in Louisiana.

Attagenus Pellio.—This insect, which appears to be rather rare, is described as looking like a miniature whale under the microscope. It is long, slender and salmon colored, with a tail of delicate wavy hair. It is very graceful in its motions.

Lepisma saccharina.—This insect, which is to the present writer at least, most repulsive in aspect, both as to form and color, is commonly known "as the silver fish; or sometimes as the silver louse, the sugar fish, etc. It seems to have been first mentioned in literature in Robert Hooke's *Micrographia*, published in London in 1667, in which he describes vividly the "small silver colour'd book-worm, which upon the removal of Books and Papers in the summer, is often observed very nimbly to scud, and pack away to some lurking cranny."

Hooke also gives a drawing of the silver fish, clearly showing the spindle-shaped or carrot-shaped body and the distinctive three bristles at the tail. In color it is, to the writer's eye, at least, of a peculiarly unwholesome livid gray, with a silvery gleam due to its shining scales. C. L. Marlatt describes it as being one of the most voracious devourers of books, papers, labels, etc., and sometimes of ordinary food. It is also said to feed upon Neuroptera of the genus Psocus. The head is large and blunt and the body tapers uniformly towards the tail.

A close relative of the *Lapismax saccharina* is the *Lapisma domestica* first described in 1873 by Packard and sometimes called the *Thermobia domestica* Pack. This insect is common in bakeries and shows a strong liking for heated localities in general. It is very common in Washington, D. C., and probably elsewhere in the United States. This insect is sometimes trapped in a very simple manner as follows: A box with a handle and having small holes punched along its lower edge is set upon a low support. Within the box are placed piles of paper fragments covered with starch paste and the trap is then placed in a dark corner of the library. The odor of the paste attracts large numbers of insects which find themselves unable to escape and which can be burned from time to time.

Ptinus fur.—This is a black-headed "worm," or rather larva, which is found in great numbers and is said to be "willing to eat anything." It resembles the *Sitodrepa* with the exception of the bristles and shape of the head as well as the color of the body. The adult is known as the white marked spider beetle. It is active chiefly at night when it can be found moving slowly along walls and wainscots. Chittenden relates the extraordinary fact that this insect was discovered to have devoured more than a hundred bags of cotton seed stored in a barn and had multiplied in such large quantities as a result of this rich provender, that it afterwards invaded neighboring houses, attacking clothing and organic material of all sorts. In America this insect is capable under favorable conditions of producing three generations annually.

Dermestes lardaria.—The *Dermestidae* are well known as

consumers of dried animal remains, of plants, and of furs, and many a collector of moths or of butterflies has suffered from the ravages of this little "worm" which will devour anything from a live insect to hard sole leather. In appearance the *Dermestes lardarius* may be compared to a microscopic hedgehog, bristling all over with rough black hairs. Even with a microscope of high power one finds it difficult to determine at which end of the hairy body is the head. Among books this species will be found in great numbers. They leave, especially upon the covers, rougher marks than are made by the other insects here mentioned. O'Conor gives an entertaining account of his first acquaintance with this little creature which we quote from his admirable brochure *Facts About Book-Worms*.

TUNNELS MADE BY THE DERMESTES LARVAE IN THE WOODEN BINDING OF A XVTH CENTURY BOOK

"On a summer's day, in the venerable Georgetown Library, where it seemed that the old times had kept within them the odor of past ages, as I held in my hands an open folio bound in leather, a little ridge of dust along the inner edge of the binding attracted my attention. On closer examination I found small holes near the edge of the dust heaps. Taking a penknife I raised the paper on the inside of the cover. When behold! there before me lay a little brown insect. It was covered with bristles and looked for all the world like a tiny hedgehog, curling himself in his spikes to insure protection. I continued the investigation, and in the same book soon found another, his counterpart. Here was a discovery in truth! 'This must be a book-worm,' I thought. . . .

"I had chanced upon the real, living, visible, palpable creature. A true book-worm visible to the naked eye it was, and it was possible that there were others that might be found under similar conditions. There was a thrill of satisfaction in the thought that I could verify a word that seemed to have hovered on the borderland of fact and of fiction, and to inquiry about which no satisfactory answer had yet been given in the domain of letters. . . .

"With a microscope I studied the movements of my captive strangers. I watched them as, on their backs, they clutched at the empty air with their six small claws, or buried their heads in the paper that I had placed near them to entice them to make use of their mandibles. They were evidently in no humor to do much boring, as very little was effected during their days of captivity. These two specimens were the *Dermestes Lardarius*, or larvæ of the brown beetle. . . ."

The *Dermestes lardarius* is known as the larder beetle in English and sometimes by the name of the bacon beetle in France and Germany. This insect is readily distinguished from all other species of the same group by the striking coloration of its elytra or wing cases whose upper portion is crossed by a large whitish band decorated with six black spots. The adult insect, which does but little damage, is about 68 mm. in length; in shape it is an elongated oval; the thorax is as wide as it is long, being rounded and tapering towards the front; it has short antennæ ending in a sort of "club" with three joints. The legs are retractile.

As we have said, this creature is particularly fond of leather and dried skins. During the warm months of the year the females deposit their eggs in the inside of bookbindings, generally on the ridges or edges which are in contact with walls or shelves. As soon as the larvæ are hatched they slip inside the volumes and begin their destructive feast upon the latter. It is a curious fact that the larvæ are much larger than the adult insects. They have elongated bodies somewhat spindle-shaped in form and ending in a truncated cone furnished with two curved "horns." The skin, which is extremely hard, and coriaceous is chestnut brown on top and yellowish white beneath. It is covered with long red hair, bristling like the quills of a porcupine. Its head is rounded and scaly with two small antennæ and six small ocelli on each side. The body, including the head, contains thirteen segments. The mandibles, which are "toothed," are extremely strong. During its period of growth, which is very rapid, the larva "moults" four or five times, the discarded integument remaining stretched like a blown-up balloon, so that it closely resembles the larva itself except that it is transparent and paler.

The young larvæ do not excavate regular tunnels like those of the *Anobiides;* on the contrary, they travel hither and thither according to caprice, thus producing quaint and intricate patterns or arabesques on the covers of books. This richly decorative, if destructive, effect is shown in our illustrations.

The adult insect generally enters houses in May or June for the purpose of laying its eggs. A close relative of similar habits is the *Dermestes vulpinus* or "fox beetle."

Anthrenus varius.—This larva is oval-shaped, and varies in form between the almost round *Dermestes* and the elongated *Attagenus pellio.* Like the *Dermestes*, it prefers the bindings of books, while the *Sitodrepa* and *Ptinus* take kindly to the paper.

This insect is commonly known as the carpet beetle but it is extremely adaptable and is quite willing to live on furs and other clothing, upon upholstery, and upon books, according to circumstances; likewise it readily adapts itself either to indoor or to outdoor life. Out of doors it is principally found among the flowers of the *Verbascum*. Whether indoors or outdoors it is found from March to October. In heated houses its eggs continue to hatch all through the winter and the spring.

It is a fortunate circumstance that the larvæ of these insects are attacked by certain parasites, Ichneumonidae. E. Olivier mentions a small Arachnid, red in color, which lives in the dust which collects on bookshelves and in wardrobes, and which makes an active hunt for these larvæ; he has even seen such a spider seize and devour an *Anthrenus* larva much bigger than itself. It seems probable that one or the other of these natural enemies might be used to keep this pest in check.

All of the *Coleoptera* described above have been actually

found in the libraries of the United States by Mr. O'Conor, and this is especially interesting in view of the fact that the standard authority on the care of books, Mr. William Blades, has assumed that the great damage done in libraries by book-worms is mostly a thing of the past, believing the adulterations of modern paper to be the reason for this, and remarking that "his instinct forbids him to eat the China clay, the bleaches, and the scores of adulterants now used to mix with the fiber." Mr. O'Conor, however, gives many specific instances of recent damage done by book-worms. The following passage from his monograph is of special interest:

"On another occasion I surprised the worm at work on bound volumes of the SCIENTIFIC AMERICAN of the years 1873 and 1875. Professor Riley, to whom I reported these facts, agreed with me that the claim that only old books were in danger and not recent books of modern paper, could not be maintained in face of such testimony. Therefore the theory of Mr. Blades that the book-worm will not eat modern paper vanishes into thin air, but the destructive work continues. It must be admitted as true that the older books run the greater risk for they are less used. . . . No true book-worm would deign to touch a popular novel. But from the security of new books a librarian may unwisely argue that older and more valuable volumes are untouched."

OTHER INJURIOUS INSECTS.

Book-mites and book-lice.—The book-louse, which when without wings is called in America the book-mite, belongs to the family of *Psocidæ*. Its most essential characteristic is in having wings with very few ribs. The mandibles are very strong and dentated on the inner edge, while the jaws are provided with a crushing device. All of these insects live upon dried plants and organic matter of all sorts. In spite of their very small size their habits closely resemble those of the destructive white ants or termites—five species are known.

Ants.—Some species of ants, e.g., the *Lasieus fuliginosus* make their nests of paper, and for this purpose they gnaw into fragments the leaves of books to which they have access.

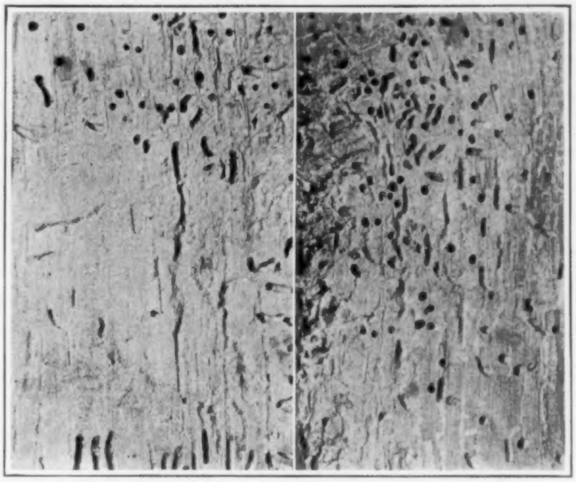
Clothes moths.—Clothes moths are all small *Lepidoptera* of nocturnal habits. The frequency with which they singe their wings at lamps or candles has become a proverb. They are pretty little creatures of various colors covered with an iridescent "bloom" or dust. The four most dangerous species are the *Tinea tapetzella* L. which devours woolen goods; the *Tinea sarcitella* L., the commonest of all, which devours our winter garments; the *T. pellionella* L., which snips off the fur from skins and garments to make itself a comfortable shelter; and the *T. flavifrontela* Fab., the "yellow-browed" moth which is such a scourge in the collections of birds and insects in museums.

The caterpillars of all these insects live within sheaths which they carry about with them. Consequently it is sometimes very difficult to perceive them even when closely examining the stuffs which they have injured; sometimes the insect digs a sort of covered tunnel outside of which the fibers of the fur or cloth are absolutely intact, while sometimes it shelters itself within sheaths which look exactly like the stuff from which they are made.

Probably all these species of moths are capable of attacking books and in some cases it has been proved beyond a doubt that they have been actual scourges in libraries. Houlbert states that even the apple-worm is sometimes accused of belonging among these ravagers of books!

Acarians or "mites."—These minute creatures belong to the *Arachnida* or spiders. They are rarely dangerous in libraries, being in fact sometimes quite helpful, on the contrary, by destroying the insect enemies of books. However, Dr. A. Hagen reports the finding of one species, probably a *Tyroglyphus*, which might become a dangerous enemy of collections. A curious instance of a plague of the small red *Acarian*, known as the meadow-mite which occurred in New York in 1893, was reported to the Division of Entymology at Washington by Mr. F. Smith. On February 2nd of that year, these insects appeared in millions, covering the windows of houses, though at this time each individual was scarcely bigger than the point of a needle. By May 26 they had reached their full development and for a week, writes Mr. Smith, "they covered everything in sight, windows, books, furniture, carpets, sofas, etc.; they disappeared about the middle of June, leaving countless rows of white eggs in every crack and crevice of floors and walls.

The *Cheyletus eruditus*, a species of mite having pincher-like mandibles, sometimes called the book-mite, is not really injurious to books but is, on the contrary, useful because it destroys the *Posocidæ*.



WOOD SPLIT TO SHOW THE TUNNELS BORED BY THE DERMESTES OR "GIMLET" BOOK-WORM

REMEDIES PROPOSED.

Various remedies have been suggested for destroying the insect enemies of books. Best of all, according to all the authorities from Horace down, is their constant use, provided they be carefully handled.

Some librarians put their faith in pyrethrum; others sug-

CONDITION OF A PIECE OF PINE BARK INFESTED WITH A WOOD-EATING INSECT

gest mixing horse chestnut flour or even corrosive sublimate with the paste used in binding; other remedies suggested are benzine, carbon disulphide, turpentine, formol, cedar oil, and camphor. Mr. Prediger suggests rubbing the books in March, July, and September with a mixture of powdered alum and pepper on a piece of woolen cloth, whereupon Mr. O'Conor makes the following cynical comment: "This rubbing with alum is very much like the cold water treatment. It is not so much the cold water as the treatment that cures. So, it is not the alum that is important, but the rubbing. Let the librarian not confine himself to any particular month, but twice or thrice a year let him overhaul the library, dusting each separate book, not with a duster but with a cloth. Wipe rather than dust. Expensive? Very well; let a worm eat one expensive volume and then count the cost. There is no use in trying to hide a patent fact. Some shelves, even in the best managed libraries, are permitted to receive and retain a layer of dust; and where there is dust, poor ventilation, and lack of light, sooner or later the book-worm will enter in and devour. The eggs of the insects are deposited in the dust. Under favorable conditions of quiet, heat and bad air, the eggs are hatched, the book-worm is alive and hungry, and the work of ruin begins. Where will it end? When will it be discovered? Oftentimes only too late, when some great literary treasure of priceless value has been utterly ruined."

Prof. Riley advises the baking of books in some cases, care being taken to keep the temperature below a point which would injure either the leaves or the bindings.

The Psychology of Business Hours

The Necessity of Freedom from Office Distractions

By Dr. George V. N. Dearborn, M.D.

THE primary purpose of this article is to suggest, partly by supposed examples, some of the applications of modern psychological thought and practice toward the hours of business. The intent especially is to make plain certain criteria which may be useful for other business executives, for the man of "big business," for the advanced business man, so to say. These criteria are only to a less extent applicable to the "hack-workers" who are sometimes found useful even in business. The work-hours of this latter group always in large majority, must be determined more by matters of expediency and of rule, by custom, even by trade-union exactions. One of the objects of the present writing is to point out the contrast between these two groups of business persons in this respect, that the former group, the executives, may realize the better that their business-hour schedule scientifically speaking is in certain ways "out of joint." To anticipate the denouément of our little story, it needs *revision downwards* in very many cases.

Business men have said that one hears too much (among the advanced masters especially) of business-hours, of definitely set periods when the corporeal man at least must be in his particular own office more or less "private," more or less, often, a cell. Great things have been created by patient time-service in cells, it is true—but greater things outside; and more of them; and more human things. And business is eminently human, the very essence of human activity in every grade of life above the cannibal. None the less, in certain respects it needs humanizing, and its production and profits will increase as well as its popularity, when it gets this scientific quickening. In the partial humanizing of industry the executive has been forgotten; and he too often forgets himself—until it is too late.

It is part of the tendency of industrial life of all kinds in America to over-value tension, speed, *quantity* in short, and correspondingly to under-appraise quality. Yet to pure common sense quality is a higher thing than quantity (save in certain symbolic values such as money). Hours stand for quantity.

But in the direct production of the working hours of business people of the executive classes, this quality-preponderance is wholly obvious. It will readily "go" almost without any saying at all. Quality (vigor, freshness, originality, ingenuity, novelty, skill, in short), as any business man would admit, is greatly more productive than quantity usually can be. Quantity as such can be bought in unlimited amounts, but quality less easily, and very seldom indeed in your own quality for your own business. "He who would be best served must serve himself." Steady routine, arithmetical hours (unless in an exceptionally secluded and homelike or even recreative atmosphere) tend to lower the quality by depressing and efficiency lowering monotony if by nothing else. One's habits must be left partly free, thus giving to skillful initiative all its proper opportunity. This is the burden of our present experience-song as business men themselves have sung it, now and then, for many years.

For one thing, as a prominent industrial leader recently said, after dinner, many business-folk fail to look far enough ahead often enough. They tend not be over-thoughtful about themselves and the methods of their minds, and the lasting vigor of their own (and only) bodies. Even "success" is an irony and a reproach when its victim dies 10 or 15 years before his ancestral time from excessive application at the office, over-worry, under-exercise, often with over-eating added—the business "race that kills." But this epidemic of unintended suicide of Americans is not our present theme, however wise and timely this observing gentleman's remarks.

For business purposes the business man's or woman's day is divided into work-time and play-time, using the term play in this case for all expense of vital energy used not as work. The ideal of hygienic industrial science and of business alike is to make the work like play! To some readers this notion, doubtless, sounds visionary and illusory, but positively it is less so, certainly, than it now sounds. "Work" is often mistaken for drudgery, whereas in reality work propertly adapted to the worker is one of life's most dependable and persistent pleasantnesses. It is toil that hurts. As for executive, "high-grade" work, for the highest at least; such work of the most productive and important sorts can be done in play-time, not only by the subconscious aspect of the mind, but also by conscious effort, sometimes without disturbing the spirit of play and of rest. One hears it said that that business man is fortunate who has the power, especially if made habitual, of leaving his business locked up with his ledgers in his office at night.

A prominent broker of Boston is the wonder of his cronies and his neighbors in Winchester in this respect. The minute he leaves the office he is essentially a boy again and the delight of whomever he associates with. One would think he never had a business or other worry in his life. He replies in answer to compliments as to his extraordinary (apparent) youth: "I'm leading the scientific, the psychologic life—and I've the persistent will-power to put it over, that's all." Certain it is that he makes the happiest adult companion, and so the happiest home, the writer knows of. Some men and women obviously are getting, and giving, the benefits that the science of human nature is now learning to supply.

This principle of mind-control undoubtedly applies to worry, to anxiety, to one's annoyance, to every kind of apprehension; it need not apply to one's proper work, adapted to the worker. One never need be afraid, even on holiday, of properly adapted

work—but only of its more or less needless disquietudes and worry. Multitudes of business-folk have discovered these facts for themselves; and science confirms the discovery.

Even the business man may advantageously listen sometimes to the products of recent psychological research. For example, to this: The business person may well learn to leave more, perhaps much, of the solving of hard problems and the elaboration of detail, even, sometimes, to the less obvious, more internal, "subconscious" mental processes. And "the subconscious" so understood, will not worry, and has no fears, at least whenever it reaches consciousness, so that we can realize them; its real fears, as Frued has shown so dramatically, show themselves in other ways.

The subconscious aspect of mind is not a chimera as a few used to suppose. But until recently it has been the one phase of mind most neglected by psychologists, and that for reasons sufficient, but unrelated to our present discussion. If one compare the stream of mental action to a river, the subconscious part is like the mass of water, while its conscious aspect, of which alone we are continually aware, the only part we "feel," see, hear, smell, taste, etc., corresponds to the ever-flucuating surface of this on-flowing stream. So many recent books and articles everywhere have described "the subconscious" of late that scarcely more need be said as to its reality and its preëminent importance in our lives. It is necessary, however, to emphasize one thing: This subconscious or unconscious part of our minds dominates our actions to a very large extent, however little we may be aware of it. I think it is obvious that the average business man so far has not applied this psychology of the subconscious to his own needs. Psychology has just found the time to do it, in part, for him. Those who would do their own delving into the deep recesses of their minds for themselves, may well read Von Hartmann, Wm. James, Henri Poincare, Morton Prince, Schofield, Addington Bruce, R. W. Emerson. It is an absolutely interesting and even dramatic chapter in the long continued story of mind; its method is that of the best, that is most thrilling, detective stories—devious workings in the dark.

Business technique, like all others, is a development, an evolution, and as such must of necessity be forever changing and improving, or it slides back. The rules and the customs of yesteryear are today partly obsolete and outgrown. Business might well adopt the James pragmatic attitude: If it works well, it is right. The least the business person can do who wishes to make the most of passing things, is to "try out" the agreeable suggested applications of modern scientific psychology. No longer must the intelligent magazine reader, not to say reviewer, shy at the Greek spelling of the first syllable of the word psychology! Multitudes to whom "Sicology" would seem a lady worth discussing one's difficulties with deem the very same lady by the name of Pyschology too "high-brow" for mundane business affairs, office troubles included. But we are changing all that since the war, as many a business man is effectively proving.

Thus, for our present purpose, human-nature wisdom distinctly suggests that office hours often may be shortened, even on the basis that office hours are the time for making numerous decisions, for meeting others on business matters, and for doing those numberless business things that can be done only by oral conference with one's business associates. For most executives and "big-business" men and women more often than not these hours, even as they are, are needlessly long. Like the artist in literature, music, painting, sculpturing, etc., the business-executive is a creator, a person methodically using ingenuity, originality, skill, and all the other mental faculties and processes of the highest grade. As a creator he is entitled to the same freedom from time-service universally accorded the painter and the musical composer. Creation arises mostly from the subconscious associations of the brain and the mind, and these go on often best at times not measurable by the seconds-ticking clock, and in all sorts of places, even the most unlikely.

This was just about the argument put up by one of the ingenuous general managers of a great near-Boston concern recently when the family directors, somewhat old fogyish in the antiquity of their "institution," to set it mildly, actually inquired of him formally why he was so seldom in his office when called on. "You expect me to do the thinking for the business end of this company and sell it to you. I'm game for that, gentlemen," he said, "but when you expect me to do my own thinking in your own way and hours, it's a bit too thick." It is said in the works-office that he made other remarks about office boys keeping school, etc., scarcely fit for publication in a calm and sober magazine. Be that as it may, his brief lecture in modern psychology, applied, made an impression on his politic hearers and employers, for certain is it that this man now seldom can be found in his office save by appointment. And the last six months of the business suggests to passers-by that he is still thinking—and certainly where and when he pleases. Each of us has an unique thinker, and Mr. H—— had found that his creaked and squeaked and got hot under the collar and worked badly in general in the tense and formal atmosphere even of his own "private" office. This man seems to be more of a psychologist than he would have admitted had any one accused him of it.

Just as one "learns to swim out of water," so, and by the same universal process of the subconscious, the business person often can do the very most important things he has to do at all on the golf course or at home busy and happy with the wife and kiddies. Give the subconscious its opportunity by refusing to mechanize yourself! Mind is not a machine.

As quality becomes more and more important in a man's work, his business day should tend, in the long run, in general, to become shorter. The scientific basis of this principle is the difficulty of doing new and unusual things, of all new adaptations to one's environment. This greatly increased mental difficulty makes shorter hours plainly necessary for continuous efficiency if one is to go on without chronic fatigue. One has to allow also for work, especially thought work at home, etc., perhaps at night when every less thoughtful employe is sleeping. Five hours daily, exclusive of the breaks (recesses, see below) ought as a routine day for any executive to be enough; sometimes certainly even that much is unnecessary, and if unnecessary then unprofitable. The Master Subconsciousness works as well, broadly speaking, in one place as in another—as well in one's car (on the rail or on the highway) as in one's private office down town.

One of New York's busiest and most constructive theatrical producers years ago discovered that his free brain works better out of his pleasant Manhattan office than in it. In all but the busiest part of his year, mid-summer, this applying psychologist does not leave his Long Island home until ten o'clock or after, arriving at his office about eleven. He finds the most important letters of course ready for his answering, and a few admitted people awaiting him. But both of these classes of communications are disposed of by one o'clock. Then he goes to lunch at a hotel with a dozen or half a dozen managers, who spend a jolly and profitable two hours or so discussing matters of various striking sorts. Sometimes he is back in his office by three o'clock, but quite as often his afternoon "office hours" are kept on the golf links, where he practices the prolongation of life as well as golf and the plans of show-producing. Doubtless many playwrights and still more numerous actors and stars of all the leading magnitudes wish his office hours were longer, but the "efficiency engineer" can not help commending his division of his busy day. He knows "by instinct" that he can think to the best business advantage (to ignore the health factor) when he is free.

This man, whose name is an American "household word," insists to his intimates and coadjutors that more time outside (shorter business hours) for the executive generally is a means to the wider view and so a more intelligent and more generally successful "adaptation to the social environment." This is another point, then.

Shorter business hours does not mean that the hours one keeps should be less accurately, conscientiously, and systematically kept. One's business associates of course must know when you can be depended on to be in your office, even as the doctor, though perhaps less importantly, sometimes.

"Routine half-hourly breaks in business hours, however 'rushed' one is would be good psychology," says one unusually successful hustler, and goes on to explain that under usual conditions one no longer expects concentration of mind for long periods, but only concentration for strong degrees of effort for short periods; this matter is of basal importance. One's private clerk should see to it that these breaks are afforded his chief and employed by him for a change of interest and of posture, etc., for 10 minutes or so each half hour. These are good times for quick but frequent inspection of works, offices, etc., and for the gradual human acquaintance with one's employes. The tendency of these breaks is anti-snobbish as well as hygienic, and so all to the good; they make for better human understanding between labor and capital, employe and employer, which above all else psychology urges upon industry and business.

The mechanical stenographers (by phonograph) make our contention of the need of less-long and less-fixed office hours still more important than it was before they came into use. Advertisers call attention to this feature of their use, and it cannot be gainsaid. When these machines become reasonably priced, their use sooner or later is certain to be univsrsal in all but the smallest offices because of this if for no other reason. But there are other obvious reasons: one can take them along on a trip as one cannot readily take a living stenographer! And some people, more especially, can talk better to themselves than to another person; but we are concerned here chiefly with the shortening which they afford to business hours.

Pleasant emotion tires far less than unpleasant emotion of like tensity. On this account the psychologist may properly in the abstract partly deplore the adoption of mechanical stenographers.

Humor is not out of place in business hours. It is the "3 in 1" oil of life, making for happiness, efficiency, and real success. Heaven bless, indeed, the amateur humorist and good-humorist, (whatever it may be found expedient to do with the humorist by profession!) He makes the business office and its worries a place to think pleasantly of, after all; and gives to the passing office minutes, however full of dissatisfactions at times, the glamour of human nature at its best—the benign and blessed influence of joy, index of ten of the highest creative powers of which the mortal business man is capable.

It is the emotional aspect of business that fatigues, and not the "purely intellectual" processes such as planning, calculation, etc. In proportion as a business has emotion in it, for another point, then, business hours should be short. For such business folk as cannot shorten their business time to the day that is strictly ideal for the executive, it is all the more essential that business hours should be pleasant hours, or at least not unpleasant. Good humor is the superficial way of keeping high the ratio between energy-expense and enjoyment. More systematically it is a matter of variety; of "success"-atmosphere; of coaxing rather than of driving; of good mental and physical hygiene; of encouragement of all kinds. This, too, is all sound psychology, but a little outside our present theme.

Routine "four o'clock teas" in form adapted to the conditions in each case, in my opinion, are time and money and bother well expended. They help mutual acquaintance, promote the "human" element, increase the mutual respect and regard by way of association, to say nothing of the material sustenance and stimulation when these are needed most.

The time of day of hours for business for the executive is not preferably too "early" in the morning, despite Mr. Updegraff's recent examples. Morning is the meeting-time of ideas; then too the joy-efficiency ratio is highest, and the worker's energy freest. Late in the forenoon, (when the central nervous system, the brain and spinal nerve, have got into swing, and reached their momentum, and keenness of association) pure inventiveness perhaps, originality, is at its freest and best. My own observation would agree in psychologic sense with the ancient British habit of coming to business in the latter part of the forenoon. It is based on the soundest science rather than on "national sleepiness."

If one's work is such as to be within, say, four hours in office daily (and with due appreciation of modern ideas of quality and of quantity, of the stheneuphoric index, of the mechanical stenographers, etc.), the forenoon, rather than the afternoon, is the time ideal. One of the busiest and most constructive executives I know, a man who had good hygienic training (even in his "great university" course) keeps office hours most days from 9:30 until 1 P. M. He tells me that from his arrival until eleven o'clock he is doing more or less routine things; that about eleven he has "trained his sub-conscious" to do its most original and its best on the day's chief problems. But the real secret of this man's always amazing mental productivity seems to me to be more in his inevitable rapid walk (he lives in the semi-country) from eight until nine every morning, his usual fifteen-minute nap while spread out flat in his darkened bedroom after lunch, and his hours of sleep each night when no important social engagements prevent. He insists that while he is a working man he will work as efficiently as his intelligence and his information (respectively native to him and purchased) can show him how. He thinks he will get his "pile" early (it looks now as if he certainly would!) and then enjoy his evening-freedom all the more. His smart morning walk, his after lunch naplet, and his nine hours of sleep all combine to furnish the ideal quantity and quality of nerve-force for his habitual business inspirations late in the forenoon, led up to during his morning walk and more or less familiar scenes. He thinks much in and out of his office, but he never worries about business. He is right and broad in thinking that even business isn't worth it!—not to a real human man or woman.

One should not sit at one's business desk too long at a time, but frequently move about resting one's eyes, rearranging the distribution of blood about the body and breaking up the office hours' monotony, however strenuous. The condition of the best mental work is frequent change. No man can sit still an hour and be mentally as alert as he might be.

Fatigue comes in to reinforce this plea with its new psychology and physiology. More and more obvious to science are on one hand the abnormality and on the other the importance of fatigue in work, indeed in any human, any animal, process where true efficiency is the criterion of judgment of conditions or an end in itself. Here business has much to learn. A research made by Friedrich in 1897 showed how distinctly fatigue works on schools boys in the work of taking dictation, of being dictated to: In the morning before school began the class made 40 errors in a given piece of work; after an hour of school lessons, 70 errors; after two hours, 160, and after three hours 190 errors—a 400 per cent increase. The average business woman or man perhaps would make fewer errors and show less sign of fatigue than boys, but surely only at an extravagance of energy wholly unjustifiable when not expedient for other reasons. The moral of this simple research by Friedrich every business person should realize and use in the planning and conduct of his work.

The ideal conditions for thought (business execution of all kinds is the realest kind of thought) are not met in office hours under usual conditions. This may be noted although almost too obviously to require mention. And it is thought that counts! It is quality, and it is quantity. Perhaps, I may be permitted to repeat a paragraph from the chapter "Is Your Thinker in Order?" from my recent "*How to Learn Easily.*"

In discussing learning to think, there are six practical points to be noted: (1) a realization of the necessity and joy of thought to education and to success; (2) development of interests as varied as possible, provided they be not too

diverse and numerous at the same time; (3) an abundance of clear ideas ("concepts"), especially of relationship; (4) a habit of concentrated attention along more or less "rational" or logical lines; (5) a thought-habit developed by practice (writing, debating, reflection), and (6) the opportunity for thought, time and relative solitude).

Business, like all other things worth doing, requires more thought, more deliberate, leisurely thinking than it usually gets. It is thought that counts, but because supposedly "difficult," and therefore often not habitual, few practice it. Hence only the few, (these are the thoughtful minority) "succeed" to the utmost. Thinking is really not hard to do; it seems so to many, only because it is unfamiliar—but like swimming (and so many other pretenses) it seems "so easy to do when you know how." And clearly that so few know how to think is not the inherent fault of the individual, but of the antique, medieval, traditional educational system which still retards our civilization and the progress of so many kinds. The business executive, frankly speaking, needs to think real and ever new thoughts, thoughts new for his particular mind whether for others or not. But the average office is no place for thought, psychologically speaking—unless it may in certain cases acquire the "free" qualities of a freer environment; and this is a difficult acquirement for the average, yes, for any, business office. The practical corollary of this basal circumstance is: More time in a much freer environment, i.e., shorter business hours, for more time in the great outside. Some busy, yes very busy, "ship owners," "way down East" (as far as Portland) have made an extraordinary success of their work on this basis: They do a lot of intensive thinking, getting a great deal "thunk" as the college boys say—but office hours are to them practically non-existent.

Thought for the business person is too often not pure thought at all, but is apt to be thought-action, thought which flies off like sparks from an emery wheel in use, a by-product whether deliberate thought or not. But business problems require much "pure" thought, deliberate thought at a special time used for it alone; when one cannot only make thought of business, but business of thought!

So the business man is obliged to use time outside his set hours, however numerous; all who are real business masters know and practice this, of course. They have to do so. My present immediate plea is that the advanced business life be still further modernized and naturalized, and humanized and hygienized, mentally and phyically, by men's trusting still less to a set business day of mechanically definite hours by the clock on the wall. And that they trust their success and progress much more to the wide and versatile constructive mentality that is in each of them. Let the "thinker" work wherever and whenever it may chance to do its advanced grade of creative business. Thus will the business person be more human (i.e., more of a man or woman in a social community), and also more constructively and executively efficient—there's not a doubt of it. Some manage to get ahead certainly with a minimum of constructive deliberate thought, but with what a handicap! For emphasis sake, so that no possible reader may miss the idea, so often expressed by men of large affairs, it is repeated that in proportion as business work is routine, and mechanical, and familiar, and "hack-work," these suggested conditions do not apply; while in proportion as the work is skillful, constructive, free (planning, the devising of novelties, etc), they do apply. Our present point may be summarized in advance by reflecting that much of the more important business work of the executive and the "big-business man" requires for its thoughtful conduct an immediate environment less monotonous and freer than the average office, however complex and private, affords.

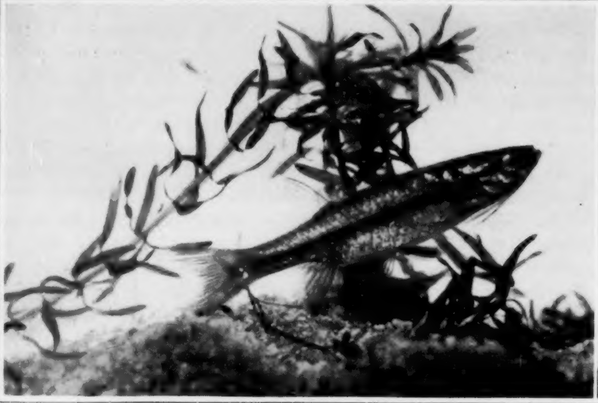
I am confident that an "applied psychologist" who tried could suggest a variety of business office, and how to build and equip it, which would meet the requirements of freedom for its users, at least, in those cases in which space and money were available in sufficient amount. The "slogan" of this office-plan would probably be: Unhurried and unworried personal opportunity! A business-thinker, untrammeled by insistent distracting actions. An environment, spiritual and physical, in which the joy-energy ratio might readily be high. Such plans would be well worth while in certain elaborate business circumstances. For the most part, however, it is more expedient and practical to have the business individual go to the thoughtful environment instead of trying to bring the ideal environment into his business establishment.

The psychology of business hours suggests one more thing. The vast majority of business folk either "hustle," or reproach themselves as inefficient if they do not "hustle." Now hustle is hurry and hurry is waste, oftentimes of material production, but always, I believe, in the life-long efficiency of the business person even considered as a machine, which a human being never is. Business hours, then, should be orderly and unhurried, and therefore unworried and efficient to the maximum, "Haste makes waste," waste usually of business production in the long run, and always of life. If one wishes to wear out early, hurried office hours are well from the hurrier's point of view. Their length has nothing to do with this; it is a matter of inner motive and feeling and of outer atmosphere.

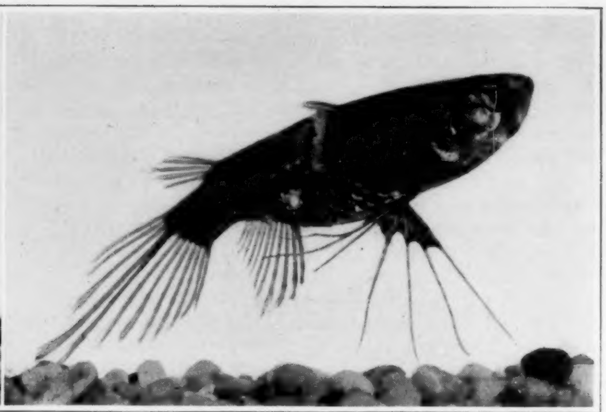
The issue here is a clean-cut issue and cannot be denied. The busy business man (the overworked business woman has not emerged into prominence as yet) who wishes really to live as long as he can and meanwhile in decent happiness, must learn to hygienize and especially to humanize his office hours in various ways so that they will be less deadly. He must so alter his increased out-of-office hours that they shall not waste his central nervous system, his heart, his arteries and his kidneys long before their ancestral time. In the "organization" of business, few things seem more in need of reform or to be of more basal importance than keeping alive many of the best of our business-masters so that they may enjoy their "success" *longer, after* 55 *years of age.*

The feeling, or the idea even, of hurrying (*fear* lest there won't be time) is the commonest and therefore in the large the most important, occasion of worry,—and worry is the stalking pestilence of the business man snatching him early hence. A trite, a gloomy, but an insistent theme is this hurry-worry, and yet in America the most important of all that concerns the personnel of business. On general psychological principles, the normal individual, who knows better, will not continue to harm himself, and the difficult problem of all hygienic reforms becomes the befitting education of the public. In business-worry this scarcely can be the case, for every young business man nowadays inevitably must realize the dreadful and needless slaughter of business men in America, after 50, from arteriosclerosis and like effects of chronic over-strain, mental and nervous. The worry-of-hurry is the infectious agent without a doubt, and it frequently gets spread about in luxurious automobiles though never on the golf-course, or along the trout-streams of Nova Scotia. The hygienic (if not the bacteriological or medical) name of this deadly pest is certainly (or it ought to be) ***Bacillus hustlecus.***

As Walter Dill Scott suggests, every business youth, on beginning his or her business life, should adopt an avocation, a fad, some outside interest, only less absorbing than his business, and should continuously cultivate it as a foil, a rest, a saving grace to his business. Provided this fad on unbusiness like interest be one not too narrow and one not too difficult and fatiguing, the recipe is fundamentally an important one for this matter of business-hours as well as for personal hygiene in general. For it will solve the danger of "unpsychological" business hours as no end of pages could but fail to do. But the ideal fads and avocations will take the business folk more and more where they can do much of their work and do it best—in God's and man's Great Out Doors. Were such a flippant mode of expression not improper in such a discussion we might well advise the over-worked executive to be often off in office hours.



THE "FLYING DART"—NURIA DANRICA



THE "WATER BUTTERFLY"—PANTODON BUCHHOLZII

The Habits and Habitats of Flying Fish

Is Their Flight Mere Volplaning?

By May Tevis

NOW that man has seen his age old dream come true of the mastery of the air he is more interested than ever in the mechanism by which flight is accomplished, not only in birds, the past masters of the art, but in other creatures which have acquired the art of sustaining themselves in the air by means of wings, fins, or the tautly stretched membranes which in some cases act like airplanes, parachutes, or the surfaces of kites.

The flight achieved by certain fishes is of peculiar interest because of the circumstance that all other creatures breathe with lungs and therefore suffer no difficulties of respiration except at unaccustomed altitudes. But fishes take in the oxygen necessary to support life through gills and these are incapable of functioning except when moist, and as a consequence they are unable to remain long out of their native element, even when able to propel themselves through the atmosphere for considerabl distances.

The fishes which have acquired the adaptation necessary for the accomplishment of this feat are found in tropical and subtropical countries in various portions of the globe. Most of them are marine animals, but three kinds inhabiting fresh waters have been discovered in comparatively recent years. Chief among the latter is the pantodon, which will be hereafter described.

Turning to the marine fishes we find that the faculty of flight exists in its most perfect condition in two widely distinct families, one of which, the Exocœtids, belongs in the group of unarmed, soft-finned fishes, called Synentognathi, while the other family, the Dactylopterids are armed fishes related to the Gurnards.

Whether marine or fresh all fishes capable of sustaining themselves in the air do so by means of an adaptation consisting of the elongation of the rays of the pectoral or breast fins and a corresponding extension of the membrane which connects the rays. The rays to some extent correspond to or are homologous with the digits of the wing of a bat or bird, and the "wing" of a fish is therefore more like that of a bat than that of a bird; the wing of the fish, however, corresponds only to the distal portion of the bat's wing—that beyond the carpel bend.

The fishes are buoyed up in the air by this greater spread of surface, which may be regarded as corresponding to the planes of a flying machines. However, the initial impulse for rising into the air is furnished by the tail fin, the muscles of the breast fins being but little more developed, if at all, than in ordinary fishes. This comparative weakness of the muscles in the breast fins furnishes a curious contrast with the very marked development of the analogous muscles in bats and birds.

THE EXOCOETOID FLYING FISHES.

The exocœtids are usually considered the true flying fish family. One of their characteristic features is the course of the lateral line, which is developed low down on each side of the abdomen and above the anal fin to the lower lobe of the caudal fin. The most perfectly adapted members of this family of fishes, constituting the sub family of exocœtines have both jaws rounded or simply angulated in front, and the pectoral fins are generally greatly enlarged and adapted to the sustentation of the body in the air. Notwithstanding this striking specialization of the group, there are considerable differences. All agree, however, but in various degrees, in provision for emergency by leaping from the water and by progress in the air.

A leading authority, aptly named Theodore Gill, has given the following admirable description of the structure of these fishes:

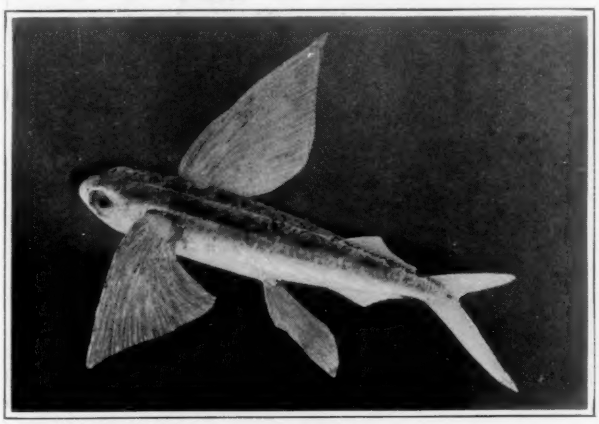
"The form is adapted for the life most of them lead; the subfusiform shape, with a quadrate periphery and with the sharp cut front, is fitted for progress in water as well as air with the least friction. The elongated lower lobe of the caudal enables a final strong upward impulse to be given to the leaping fish; the pectoral and ventral fins are enlarged with the maximum of surface to sustain the body in the air and the minimum of weight in the framework. Their foremost rays are also sharp edged forward so as to act as "cutairs" as well as cutwaters. The air bladder is greatly enlarged and filled with a gaseous emanation (mostly nitrogen), which diminishes the relative weight of the body."

While most flying fishes are found in tropical and subtropical seas a few wander into temperate areas on either side of the equator. As a general rule they are found not more than one hundred to two hundred miles from land. About 65 species have been described, some 20 of which have been found in American seas. Five species are known upon the Pacific coast only and two upon the Atlantic coast, while the others enjoy a wide range—the majority of them being found both in the Atlantic and in the Pacific.

They are comparatively uniform in size, the adult fish being rarely less than 8 inches in length or more than 18. They swim in schools which are sometimes very large. They frequently swim very near the surface of the water, moving with long, sweeping strokes of the tail and latter half of the body while keeping the pectral and ventral fins pressed close to the body. Every now and then, however, the breast fin on one side is slowly stretched to its full extent, apparently, merely for exercise. A striking description of their aspect is furnished by Hugh Smith, who found this spreading of the fins "exceedingly striking and pretty, the fin looking like silver, and when several of the fish were in company the flash caused by a fin being opened, now here, now there, now on one side of a fish, and then on the other, heightened the effect considerably. It was curious to note, when the expanding fin was closed, how completely it disappeared, altering the appearance of the fish entirely." Sometimes in sport, sometimes to escape pursuing enemies, with increased vigorous movement of the tail, they spring out of the water, immediately spread their pectoral and ventral fins, and start an aerial progress known as flight.

DO FLYING FISHES REALLY FLY?

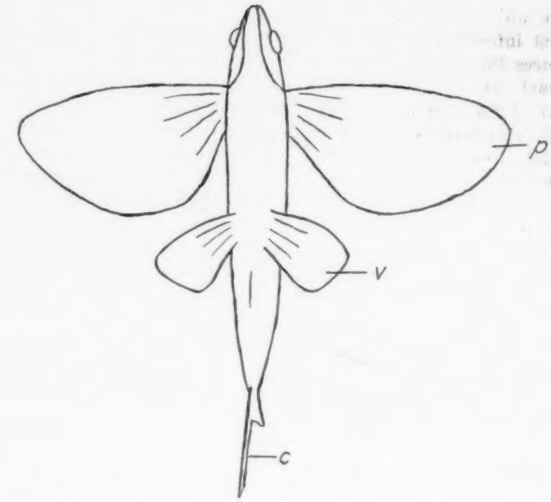
There has been much debate among naturalists as to whether the progress of flying fishes is properly to be called true flight. The answer appears to be a matter of definition. If by flight we mean the voluntary beating of the wings per-



Courtesy, Amer. Mus. of Nat. Hist.
THE TRUE FLYING FISH, EXOCOETUS

formed by birds and bats in the act of flight, most authorities seem to think that the fish do not really fly but merely volplane in the air. However, since modern usage applies the word flight to the motion produced in flying squirrels, flying opossums, flying lemurs, flying lizards, and flying frogs, as well as to flying planes constructed by man, in all of which cases the body is sustained in the air by expanded membranes, then we may say that the fish really fly.

The question was impartially and scientifically considered by Karl Möbius, who came to the conclusion that flying fish are incapable of true flight for the simple reason that the muscles of the breast fins are not large enough to bear the weight of the body in the air. The pectoral muscles of birds which depress their wings weigh, on an average, one-sixth of the total weight of the body, the pectoral muscles of bats one-thirteenth, and the muscles of the pectoral fins of flying fish only one thirty-second. The impulse to which flying fish owe their long shooting passage through the air is delivered while they are still in the water by the powerful masses of muscle on both sides of their body, which are of much greater breadth than in the case of the herring or any other fish of their own size. According to this authority, the movement of the pectoral fins, described generally as flickering, vibrating, or flapping, is only a vibration of their elastic membrane, and is to



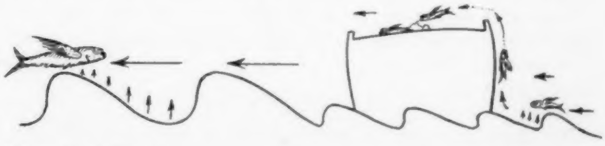
After R. Anthon
VENTRAL VIEW OF THE EXOCOETUS—*p*, PECTORAL FIN; *v*, VERTICAL FIN; *c*, CAUDAL FIN

be referred to the same laws as those which govern the flapping of a tight-set sail when a ship under a stiff breeze is driving close to the wind. Flapping or vibration at once occurs whenever the sail heads parallel to the wind.

The more rapidly a flying fish darts out of the water the greater is the momentum with which the air presses on the outspread pectoral fins. Should now the atmospheric pressure induce these fins into a horizontal position parallel to the wind their vibration is a necessary result. Let the outspread pectoral fins of a dead flying fish be held horizontally before the opening of a pair of bellows and the fins will be seen to vibrate as the current of air passes under them.

Such are the conclusions enunciated by Möbius in a special memoir (in German) on the movements of flying fish through the air (1878) as epitomized in 1885. These, however, were vigorously objected to by C. O. Whitman (1880), who urged "Admitting that in form, size, length, and structure the pectoral fins of the *Exocœtus* are less well adapted to flight than the wings of most birds, there is still ample room to believe, on anatomical and physiological grounds alone, that they are capable of executing true flight." This view is supported by Mr. J. T. Nichols, of the Department of Ichthyology of the American Museum of Natural History in New York City.

Opposed to this view are the expressed opinions of many distinguished traveler-naturalists. Moseley, who circumnavigated the globe as naturalist of the great Challenger Expedition, expressly declares that he had never seen any species of *Exocœtus* flap its wings at all during flight. Jordan and Evermann (1896), who had many opportunities for observation under most favorable conditions, were convinced that no force is acquired while the fish is in the air. "On rising from the water the movements of the tail are continued until the



After Theodore Gill
INFLUENCE OF WIND CURRENTS IN THE FLIGHT OF FISH

whole body is out of the water. While the tail is in motion, the pectorals seem to be in a state of rapid vibration, but this is apparent only, due to the resistance of the air to the motions of the animal. While the tail is in the water the ventrals are folded. When the action of the tail ceases, the pectorals and ventrals are spread and held at rest. They are not used as wings, but act rather as parachutes to hold the body in

the air." Boulenger, of the London Zoölogical Garden, the best informed ichthyologist of Europe, according to Mr. Gill, voices the general verdict in the apt declaration (1904) that nearly all the family are in the habit of making great leaps out of the water, and this tendency culminates in the flying fish (*Exocœtus*), "which skip or sail through the air in a manner the explanation of which has given rise to much controversy. According to the latest evidence, the sole source of motive power is the action of the strong tail while in the water. No force is acquired while the fish is in the air. The pectorals are not used as wings, but as parachutes."

The contention that flying fishes have the power materially to modify their course in midair is generally thought by qualified ichthyologists to be not corroborated by their structure or by exact observation. Louis Agassiz (1868), however, was confident not only that they change the direction of their flight, but that they raise or lower their line of movement repeatedly without returning to the water.

They must have leverage to work from, remarks Gill, and after leaving water they must go as their final impulse directs or as the wind determines. Even those who contend that they can direct their course may admit that when in mid-flight they cannot suddenly divert their course. Mathew (1873) observed one which emerged from the sea within 10 yards of the ship and flew directly towards her, coming so violently into contact with the ship's side that it fell stunned, and floated astern on the surface of the sea with its pectoral fins rigidly expanded. Possibly they may be able sometimes to flex the tail or fold one fin in the air and thus change the course to some degree. . . .

When the fish begins to fall, the tail touches the water, when its motion again begins, and with it the apparent motion of the pectorals.

When a flying fish falls on the deck of a vessel it may spasmodically and very rapidly move its pectorals upward and downward, and such a movement may be made while the fish is "on the wing" and give the appearance of vibration so often claimed to be observed. This action doubtless adds something to the force of the leap from the water, but it is by no means actual flight, say most ichthyologists.

It has been claimed that flying fishes are not often to be seen in periods of calm and a smooth sea; it is when the winds blow strong and the waves roll high that most of them make their appearance. Hence the belief that they foretell a storm. It is easy to understand how the action of the wind combines favorably or otherwise with their flight. As any air in strong motion, when it impinges against obstacles (a ship's side or waves) rises, it raises the fish also, so that it flies over the wave or may come on board the ship. In short, as Professor Möbius proves in detail, all the phenomena observed may be fully explained by the combined action of the oblique projection forward and the wind. Directly against the wind they commonly fly farther than with the wind, or when their course found an angle with the direction of the wind form an angle together. Most *Exocœti* which fly against the wind or with the wind continue, during their whole course of flight, in the direction in which they come out of the water. Winds coming laterally upon the original course of the *Exocœti* deflect these into their direction, as shown in the accompanying diagram.

THEIR FOOD.

The food of the flying fishes consist of such animal organisms as occur in the seas which they frequent. They are numerous crustaceans some mollusks, such as Pteropods and Janthinids, and various small fishes. These fishes are, in fact, almost omnivorous, as may be understood from the means of capture used by professional fishermen and anglers.

THEIR ENEMIES.

Flying fish are practically free from capture by birds, but many of the large ocean fishes, such as dolphins, tunnies, bonitos, and albicores, as well as sharks and porpoises greedfly pursue them. In order to help themselves escape, the development of the powers to leave the water has resulted, and most of the near relatives of the flying fishes which could not acquire the power have long since ceased to live, for the nearest living relatives belong to other groups—the Sauries and Half-beaks. The pursuing fishes are as swift and active in the water as the flying fishes, and even escape from the water serves often merely to delay capture for the pursuing fish may catch one as it falls from the air.

THEIR EDIBILITY.

Flying fishes are said to be unusually savory and palatable as articles of food; especially dear to epicures are the

After Brehm
A "FLOCK" OF FLYING FISH (DACTYLOPTERUS VOLITANS)

Cypselurus californicus described above and the *Cypselurus speculiger* of which we publish a photograph taken from an admirable model in the American Museum of Natural History in New York City. The latter was long known as the *Exocœtus volitans*, the later name being applied to it because of the bright silvery spots upon its flying fins which flash back the lights like bits of looking glass (Latin *speculum* = mirror). Thiss pecies is found abundantly in thei sland of Barbadoes and at certain seasons forms a staple food for the natives and is a dainty highly appreciated by chance visitors.

The bait used is putrescent fish and the tackle is very simple, consisting of a wooden hoop, 3 feet in diameter, to which is attached a shallow net with inch meshes, together with a few good lines and hooks and a set of grains. Gill quotes the following account of a fishing expedition from an unnamed writer: "As soon as the boat is hove to and her way stopped, the usual exuberant spirits and hilarious laughter are stilled

and kept under strong restraint, for a single sound will often scare away all fish in the vicinity and no more will be seen that day. The fisherman leans far over the boat's side, holding the hoop diagonally in one hand. The other hand holding one of the malodorous fish before mentioned, is dipped into the sea, and the bait squeezed into minute fragments. This answers a double purpose; it attracts the fish and the exuding oil forms a 'sleep' or glassy surface all around, through which one can see to a great depth. Presently sundry black specks appear far down; they grow larger and more numerous, and the motionless black man hanging over the gunwale scarcely breathes. As soon as a sufficient number are gathered he sweeps the net gently downward and toward the boat withal, bringing it up to the surface by drawing it up against the side. Often it will contain as many fish as a man can lift; but so quietly and swiftly is the operation performed that the school is not startled, and it very often happens that a boat is filled (that is, 7,000 or 8,000 fish) from one school. More frequently, however, the slightest noise, a passing shadow, will alarm the school; there is a flash of silvery light, and the water is clear, not a speck to be seen."

Flying fishes might be regarded as unlikely subjects for fly angling, but Francis Smith (1875) experimented with gratification to himself in this way. Off the coast of Peru a large shoal of flying fish appeared and afforded excellent sport. A variety of baits was employed in their capture—bits of red bunting, small spoon baits, and artificial minnows and flies—the most taking being a large red fly and a small gilt minnow, but all the baits mentioned caught some. In following the minnow through the water, the fish would open both pectoral fins and poise themselves for a rush at it; spreading the wings also had the effect of checking their progress if their suspicions were aroused by a near inspection of the bait. When hooked they proved a very game fish, taking out several yards of line in their first rush, and often taking a flight in the air, line and all.

The Dactylopterids, otherwise known as Flying Gurnards or Flying Gurnets, differ radically and in innumerable characters from the true Gurnards, and vastly more from the *Exocœtoid* flying fishes, but a few external ones will suffice to give an idea of the family. The elongated body is somewhat swollen upward under the first dorsal, and covered with hard-keeled scales; the head is oblong and parallelpiped, and the suprascapular bones form an integral part of the skull, and extend far back as flat spiniform processes on each side of the dorsal fin; the preoperculum of each side is armed at its angle with a long horizontal spine reaching backward under the pectoral; the jaws have granular teeth; the bronchial apertures are contracted; the dorsal fins short, as is also the anal; the pectorals divided into two parts, a small anterior and a very large posterior, which spread out sideways; the ventrals imperfect and not far apart. The pectorals are set upon osseous bases (actinosts) differentiated for the two parts.

As almost every external feature is characteristic, so are many internal parts. In connection with the longitudinal arch or convexity of the back, so different from the straightness of that of the Gurnards, a very remarkable deviation of the air bladder from normal relations is noteworthy; the dorsal curvature, indeed, is a coördinate of an otherwise unexampled position of the bladder.

The air, or swimming bladder, is unique in character, as Calderwood states, in that it is not situated below, but (mostly) above, the vertebral column, not forming part of the abdominal contents, but situated dorsally in a special cavity(recess) of its own. When the abdominal cavity is opened ventrally, and the viscera removed, only the ventral surface of the bladder is seen, forming part of the dorsal boundary of the cavity. Seen from this point of view, it is formed of a broad central portion, white and tendonous, and of two lateral portions strongly muscular. The physiological significance of this comes into view when we consider one of the habits or aptitudes of the fish.

The structure and position of the air-bladder are adapted for keeping the Dactylopterid with back upward in the air in spite of the form of the body and its relations to the vertebral axis. The bladder being prevented from expanding when the pressure from the surrounding water is suddenly removed, the high dorsal position of the secondary portion becomes of the greatest possible advantage. It helps the fish to emerge from the water and maintain its equilibrium in the air.

Such are the most characteristic features of the Dactylopterids common to all the members of the family. The species are few—about half a dozen—and closely related to each other, all being strictly congeneric.

The coloring of the fish as described by Gill appears at a distance and superficially as a mixture of dark tints, but is found to contain, on closer examination, a great quantity of many-colored markings. The back is colored a beautiful brown, with dark spots and bands. The sides, as far as the middle of the belly, are pale rose, with silvery reflections, and the outspread wings show in the center rows of black and light eye-like spots, which recall the coloring of tropical butterflies by their markings and gay tints, together with the magnificent blue with which they are hemmed in. This beautiful sight may be especially enjoyed when looking at the fishes from above in the sunlight or in the broad daylight, while inducing them to unfold their wings by holding a stick close to them. Then golden green specks appear all over the body; at every motion the fins play in all colors in different places, like the wings of the butterfly known as the purple emperor, and also the gay mingling of beautifully distributed tints on the head contributes to the splendor of the brilliant creature. Besides this the *Dactylopterus* possesses the protective faculty of changing its colors to light or dark. This is particularly fortunate for the young ones, where the bottom is similarly colored, since because of their small size, they are more exposed to the attacks of the enemies. It has also been observed that the young flying gurnards far more commonly stay on the bottom of the basin than the larger fishes, and here harmonize splendidly with the sand, especially where it is mixed with multi-colored gravel. Furthermore, the coloring of such specimens is also less pronounced and the markings are darker, more monotonous, and frequently indistinct. At dusk the fishes are scarcely visible. The authorities of the Naples station have to protect the basin for these fishes with bars and nets to prevent their escaping, because otherwise the would fly through the window into the open air or to either side into the adjoining tanks. And, as a matter of fact, the station loses a rather large number of the fishes because they jump out and fall against the walls, or on the bridge over the aquarium, and perish there.

THE PANTODON OR "WATER BUTTERFLY."

The beautiful and graceful little fish called the Pantodon which has been said to resemble a water butterfly because of its delicate coloring and the graceful way it flutters above the surface of the water is found in African streams, and was long supposed to be the only example of a fresh-water flying fish. Since then, however, others have been discovered in South America and in India, the latter being the *Nuria*, also shown here.

The Pantodon has four gills and pseudo-gills. Both head and body are covered with the same sort of scales. The breast fin, which contains only a few rays, is very large and is remarkable for the fleshy prolongations which are annexed to the inner ray. This fin is almost half as long as the fish's body. The ventral fin consists of 7 rays, some of which are simple and prolonged in the form of filaments. This fin is inserted farther forward than in any other type belonging to the same sub-order, being immediately behind the breast fin. The dorsal fin is placed very far to the rear, while the tail fin is very large and pointed, having medium rays twice as long as the head of the fish. This fish has very small teeth which are extremely numerous, whence the name which is derived

from two Greek words meaning "all teeth." They are conical and are borne not only upon the jaws but by the vomer, the palatins, the ptrygoids, etc., and even by the tongue.

As we have said, the brilliant coloring of this attractive little fish makes it resemble some fluttering iridescent butterfly. It is of an olive color beneath, while the abdomen is a silvery lemon color with carmine reflections. The back sometimes is crossed with very dark transverse bands. The fins are of a bright rose color ornamented with round spots of brown shading to violet; these spots form transverse bands from the breast fin.

The Pantodon is found in the rivers of tropical Africa, the Victoria (at Kameroon), the Niger, the basin of the Congo, etc. Gill is disposed to consider the flight of this little fish as being rather a brief leap from the water. However, a more recent and apparently better informed authority, Mr. A. Ménégaux, says that in the endeavor to escape its enemy it flies just above the surface of the water for a distance of 4 or 5 meters, which sometimes extends to as much as 15 or 20, beating the water with its pectoral fins so as to form a small rectilinear furrow like the wake of a ship. It flies about 5 feet above the surface of the water except when forced up by a strong wind.

It is said to be able to live for a considerable length of time outside the water or in mud and to feed upon both plants and animals.

The Nuria danrica, or "Flying Barb," has a silvery body with a longitudinal stripe of black and above red. The fins are yellowish. The mouth has four barbels, two long and two shorter ones. The male turns red-brown at the tail during the breeding time. The female is not so slender as the male and its color is less bright. The pectoral fins are large in the case of either sex.

In the aquarium these fish should be kept in water at 20 deg. cent. When they breed the water should be about 25 deg. cent. The eggs are deposited on water plants and hatch after three or four days. The Nuria like to spawn when the sun strikes the aquarium. They eat the eggs and should be separated from them after spawning. When in danger the fish jumps flying out of the water, using the long pectoral fins.

The photographs on page 504 are taken from living specimens kept in a small aquarium on Long Island.

Carbon Monoxide a Respiration Product*

Experiments with the Floater of the Giant Pacific Coast Kelp

By Seth C. Langdon and Walter R. Gailey

IN a paper presented by one of us[1] it was shown that there is present an average of 4 per cent (by volume) of free carbon monoxide in the pneumatocyst (*i. e.*, the floater) of the giant Pacific Coast kelp *Nereocystis leutkeana*.

This unique occurrence of free carbon monoxide within a living plant at once raised the question as to its origin. The intimate chemical relation of carbon monoxide to formaldehyde and formic acid had long ago suggested its possible relation to photosynthetic processes. On the basis of the physiology and structure of the plant there were grounds for the consideration that the carbon monoxide might be a product of respiration.

The possibility of its formation due to the action of enzymes or to processes of decay was the first point investigated. Finely ground kelp was allowed to undergo autolysis in contact with sea water and the gases evolved were examined. No carbon monoxide was formed, but the gas consisted almost entirely of carbon dioxide and hydrogen.

The next step was to determine how rapidly carbon monoxide was formed within the living plant. The method of work and the subsequent discussion will be made more clear if preceded by a brief description of the plant.

Fig. 1 shows the plant as it rests almost submerged in the sea water, but anchored to the rock bottom and supporting the streaming fronds from the top of the hollow gas-filled stipe. The plants vary greatly in size; individuals are often 80 to 100 feet in length and contain several liters of gas, usually at reduced pressures.[2] The inside of the gas cavity is relatively quite dry and is lined with a delicate web-like structure, known as sieve tubes. The plant will withstand a great deal of mutilation and still continue to live and grow if kept in sea water.[3]

It was found practicable to cut off the lower part of the stipe and in the upper part substitute a gas of known composition for that normally present in the pneumatocyst. The cut end was closed by a cork and the weighted plant submerged in the sea tied to a support as shown in Fig. 2. After a suitable interval changes in the composition of the gas were determined by analysis.

In the first experiments, made primarily to determine the rate of formation of carbon monoxide, air was substituted for the kelp gas. This was accomplished by filling the cut stipe with sea water and then emptying. This process, repeated 3 or 4 times, removed the small bubbles of the original kelp gas that tended to adhere to the delicate sieve tube lining of the interior. The cut end of the now air-filled stipe was corked and the prepared plant anchored near the surface of the sea as previously described.

Analyses of the gases from a series of these cut and air-

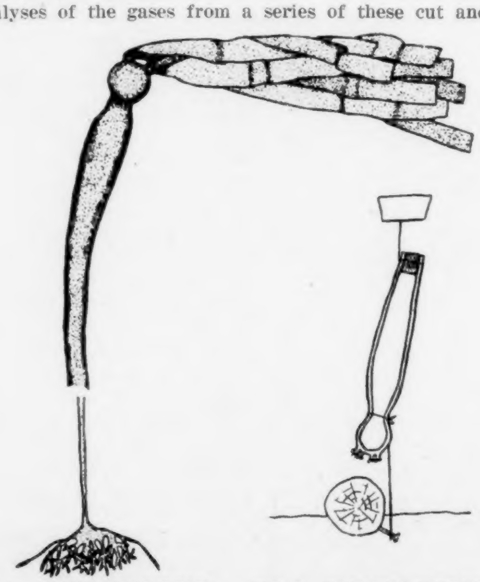


FIG. 1. GIANT KELP RESTING ALMOST SUBMERGED IN SEA WATER

FIG. 2. FLOATER FILLED WITH A SUBSTITUTE GAS

filled plants were made after various intervals of time. The typical data given in Table 1 show clearly the gradual formation of carbon monoxide. This is accompanied by a decrease in oxygen content and the appearance of carbon dioxide. The latter is undoubtedly due to processes of decay, since carbon dioxide is not present within the normal plant. In gen-

*Reprinted from *Jour. Amer. Chem. Soc.*, March, 1920, pp. 641 to 646.
[1]Langdon, *Jour. Amer. Chem. Soc.*, 39, 149 (1917).
[2]Frye, *Puget Sound Marine Sta. Pub.*, 1, 85 (1916).
[3]Fallis, *Puget Sound Marine Sta. Pub.*, 1, 1 (1916).

eral, the cut and corked section of stipe remained sound enough to be tight for a week or ten days, although evidence of local decomposition was apparent.

The production of carbon monoxide when the stipe was filled with air was confirmed by a large number of determinations with different specimens. In most cases it appeared in quantities greater than 1 per cent. Carbon monoxide was formed by sections cut from any part of the hollow stipe if these were filled with air, corked and similarly suspended in the sea. The leaves, more properly called fronds, seemed to bear no relation to the formation of the carbon monoxide for it was produced just as readily in speciments from which the fronds had been removed.

TABLE I.

Analyses of Gases in Air-Filled Stipes.

Time, start. Hrs.	CO_2. %.	CO. %.	O_2. %.
	0.0	0.0	20.8
24	0.3	0.0	16.5
48	0.0	0.4	13.0
73	0.6	1.0	7.0
97	1.0	3.2	6.2
110	1.1	4.5	5.0

In all of the experiments detailed above, the test specimens, while anchored in the bay, were exposed to the light during the long summer day. The next step was to determine if the carbon monoxide would be formed in the dark.

For this purpose boxes were constructed which were light-tight but which would allow a ready flow of water through them. These boxes were one foot square and 18 feet long. The ends were closed by light traps, the baffle boards of which were inclined in the direction of flow of the water as shown in Fig. 3. The lids were light-tight. All holes and cracks were closed with pitch and the whole interior was painted a dead black. The boxes were weighted so as just to float; the waves washed entirely over them except when the water was perfectly quiet. They were anchored in the bay (Friday Harbor, Wash.), where the tidal currents are heavy so that at almost all hours of the day there was a flow of water through them. They were large enough to hold several specimens without materially impeding the flow of water.

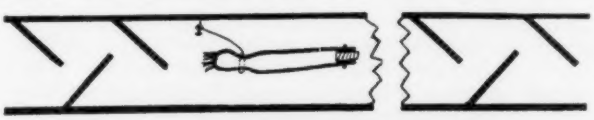


FIG. 3. STIPE ENCLOSED IN BOX TO DETERMINE WHETHER CARBON MONOXIDE WOULD FORM IN THE DARK

In the first experiment the top foot and a half of stipe from the kelp was filled with air by displacement, as previously described, then corked and placed in sea water in the dark boxes, the fronds being removed from half of them. After 5 days in the dark the gas was analyzed. All specimens showed carbon monoxide. The range was from 0.4 to 1.7 per cent with an average of 0.7 per cent of carbon monoxide. The 20.9 per cent of oxygen in the air with which they had been originally filled had practically disappeared and there was about 4 per cent of carbon dioxide. The oxygen was, no doubt, used by respiration and decay processes.

This data was checked by repeated similar series of experiments and it was made certain that in the dark as well as in the light carbon monoxide was formed regularly in the air-filled sections of the stipe, and that there was no relation between its appearance and the presence or absence of the fronds.

An analogous appearance of carbon dioxide and lowering of the oxygen content was shown when unmutilated plants were kept for some time in the dark. The experiment and results are as follows: Twelve whole plants were carefully collected from the same bed. Precautions were taken to avoid in any way disrupting the gas cavity. The gas from 6 of them was analyzed at once and showed an average of 15 per cent of oxygen, 3.2 per cent of carbon monoxide and no carbon dioxide, the unabsorbed residue being nitrogen. The 6 other plants were placed intact in the dark boxes and after being anchored out in the tidal currents for 6 days showed the following average gas composition: Oxygen 4.7 per cent, carbon monoxide 2.9 per cent, and carbon dioxide 0.5 per cent. There was thus a marked decrease in the oxygen content, an appearance of carbon dioxide, which is not present in the plants when freshly collected, while the carbon monoxide content was practically unaltered. These changes in the oxygen and carbon dioxide content produced by stopping photosynthetic action for a prolonged period throws interesting sidelights on the gas exchange equilibria within the living plant. The formation of the carbon dioxide on protracted standing in the dark shows that gaseous respiration products certainly do find their way into the interior cavity of the plant. Whether or not these gases bear only an incidental relation to the metabolic processes of the kelp has not been determined but should prove a fruitful field for research.

The substitution of gases other than air for those normally present was next undertaken.

As a result of more than 40 carefully executed experiments, in which nitrogen was substituted for the kelp gas, it can be confidently stated that *no carbon monoxide was formed*, either in the light or in the dark, either when the fronds were present or when they had been removed, or at any intermediate time between the initial filling with nitrogen and the 8 to 10 days that elapsed before decay had become so pronounced that observation could no longer be made. It should be remarked that carbon dioxide was formed to the extent of several per cent, even though there was no oxygen present.

Nitrogen prepared by three different methods was used. First, by heating ammonium chloride and potassium nitrite, then washing through alkali and then conc. sufuric acid. Second, from aid by absorbing the oxygen in alkaline pyrogalol. Third, the commercial product obtained from the distillation of liquid air. This last contained a little more than a half of one per cent of oxygen. The character of results was the same for the nitrogen, irrespective of the source.

Similar experiments were carried out in which hydrogen was substituted for kelp gas. The 15 determinations made showed no formation of carbon monoxide within 5 to 7 days, either in the light or in the dark. Here as in the case of the nitrogen-filled kelp several per cent (1 per cent to 9 per cent) of carbon dioxide was formed. It should be remarked that there was always a marked reduction in pressure for hydrogen filled kelp. This amounts to an absorption or an outward diffusion of the hydrogen. The whole relation of hydrogen in this connection deserves a more exhaustive study.

The hydrogen used was from two sources: first, the action of dil. sulfuric acid on the so-called arsenic-free zinc, and, second, electrolytic hydrogen.

A number of sections of kelp stipe were filled with a mixture of nitrogen and oxygen. The gas was 15.2 per cent oxygen and the remainder nitrogen. After 6 days' anchoring out in the sea water carbon monoxide had formed in all cases, the quantities ranging from 0.8 per cent to 2.1 per cent. The oxygen content had decreased and some carbon dioxide was formed just as in the case of the kelp that had been filled with air. Similar results were obtained when a mixture of hydrogen and oxygen was substituted for the gas originally present in the kelp.

The kelp withstands exposure very well and can remain hours or even days out of water and will resume normal activity when returned to the sea, that is, if not too severely sun burned or desiccated. Tightly corked air-filled sections of stipe were found to produce carbon monoxide, either in the light or in the dark, when simply exposed to the air. These

plants were still alive, although local decay soon set in. When the substituted gas was nitrogen or hydrogen no carbon monoxide was formed. It appeared only when free oxygen was within the gas cavity.

That the formation of carbon monoxide takes place only within the living plant was shown by its complete failure to be formed in the air-filled stipes of kelp that had been killed. Some of the plants were killed by immersion for 10 minutes in sea water at 50°; others by being placed in 0.02 *N* copper sulfate solution for 18 hours. These filled with air or other gas mixtures containing oxygen failed to produce carbon monoxide whether in the sea water or exposed dry to the air.

CONCLUSIONS.

The several per cent of free carbon monoxide which occurs in the floater of the giant *Pacific Coast kelp, Nereocystis leutkeana*, is considered to be a respiration product for the following reasons: It forms only when oxygen is present within the floater; it forms as readily in the dark as in the light; is not formed by enzyme or fermentation process when the substance of the plant undergoes autolysis and decay, and is not formed in killed plants.

The kelp, *Nereocystis leutkeana*, seemed to be remarkably well adapted to research on the gas exchange of living cells. By the use of the very refined methods of gas analysis some very interesting and valuable information might be gained as to the mechanism of plant processes. It is possible that traces of hydrogen, carbon monoxide, or other gases, not revealed by the technical analytical methods used in this work may be playing unsuspected and perhaps important rôles in plant processes.

Conditions have now arisen which make it highly improbable that either of the present authors will pursue this investigation farther, and it is with some regret that we leave this field to other workers.

This research was carried out during the summer of 1917 at the Puget Sound Marine Station, at which time the authors were associated with the University of Washington.

SUMMARY.

1. The existence of several per cent of carbon monoxide in the gas contained in the Pacific Coast kelp, *Nereocystis luetkeana*, is confirmed.

2. The substance of the kelp, when ground and allowed to undergo autolysis and decay does not form carbon monoxide by enzyme action or fermentation process.

3. Kelp plants in which the gas normally present within the floater is replaced by air, form several per cent of carbon monoxide within a few days.

4. The formation of carbon monoxide takes place only when oxygen is present as one of the gases within the floater. No carbon monoxide is formed when the floater is filled with hydrogen or nitrogen.

5. Light does not affect the rate of formation of carbon monoxide.

6. It is concluded that the carbon monoxide is formed as a product of respiration rather than as an intermediate step in photosynthesis.

SUGAR FROM PUMPKINS.

THE severely felt shortage of sugar, which is even more oppressive in Europe than in this country, has led to the revival of an ancient process of making sugar from the ordinary pumpkin. Several members of the family of *cucurbitacea* contain considerable amounts of crystallizable sugar, i.e. of saccharose instead of the glucose which is more generally found in fruits and vegetables.

The Brazilian courge is the member of the family richest in sugar since it yields a juice titrating 9 degrees in the Baumé areometer, but another species, namely, the common pumpkin of Europe and America likewise, contains a considerable amount of crystallizable sugar.

The pumpkin is easy to grow even upon ground which does not suit other vegetables. It is a sturdy plant of rapid growth and fruits plentifully even when but slightly fertilized. Its yield per acre is superior to that of the sugar beet; even with an ordinary screw-press 6 per cent of sugar can be obtained from it, while modern processes of extraction give a much higher yield.

Less care is required in the extraction of the sugar than in the case of the beet, since the pulp and the juice of the pumpkin are slower to ferment. Furthermore, the juice produces no scum when boiled and does not readily scorch. The raw sugar obtained from the pumpkin is only slightly tinted and has an agreeable flavor even before refining, in which it is superior to the sugar beet. After being refined the sugar is perfectly white, pure in taste, and fine of grain, resembling cane sugar of the best quality. The syrup of the sugar beet cannot be used for immediate consumption because of its disagreeable flavor which is bitter sweet and somewhat "weedy"; but the syrup of the pumpkin, on the contrary, is very agreeable, having a flavor which recalls that of the melon, so that it can be employed without purification.

Another advantage of the pumpkin is the value of the by-products, namely, the pulp and the seed, both of which are of use. The pulp can be kept in good condition without undergoing alteration for a considerable length of time and forms an excellent fodder for cattle, being both wholesome and nutritious, and without the strong odor of beet pulp, a feature which is very important in the feeding of milch cows.

When properly treated the seeds yield considerable quantities of edible oil, 100 kg. of seed producing 18 kg. of oil. Some authorities even estimate that this oil is capable of paying 50 per cent of the cost of cultivation.

A NEW METHOD OT TESTING THE PURITY OF FATTY ACIDS.

IT is a curious fact that when a definite fatty acid (chemically speaking) has added to it a certain amount of another fatty acid, the solubility of the first acid in the same solution is greatly increased. This phenomenon is peculiar in that the action is reciprocal and the increase of solubility is practically independent of the temperature. This phenonenon has been known for a comparatively long time, but it has been recently restudied by two German chemists, P. Waentig and G. Pescheck, in the endeavor to determine the cost of this augumentation of the solubility. The results of their experiments are given by them in the *Zeitschrift f. phys. Chemie*, for September 26, 1919. We quote the following abstract of this article from *Le Genie Civil*, Paris, for January 21, 1920.

The increase of solubility is always very great—thus the solubility of palmitic acid in carbon tetra-chloride can be increased 250 per cent by the addition of lauric acid.

The increase of solubility diminishes when the proportion of the second acid is increased—a definite limit is always reached. These peculiarities are always explained by the formation between the two fatty acids of molecular compounds which are more soluble than either of the fatty acids themselves. In the solid state there exists furthermore a similar compound formed of a molecule of each of the two fatty acids in the case cited above. This phenomenon is exhibited only when the fatty acids are not hydrolized by the sulphates, i.e., by the carbon tetra-chloride, chloroform, benzene, toluene or nitro-benzene. The phenonenon does not take place in ethyl alcohol, ether, ethyl acetate or benzoic aldehyde.

A very interesting practical application is made of this circumstance in the testing of the purity of a fatty acid. The determination of the solubility of a fatty acid is a much less complicated test, in fact, of the degree of purity of the latter than is the determination of its fusion compound. The slightest impurity and even the presence of a trace of water is sufficient to occasion a considerable variation in the solubility of the acid.

Industrial Employment of Extremely High Pressures

Production of Synthetic Ammonia

AT the session of the French Academy of Sciences on October 13, 1919, a report was made by M. Georges Claude concerning the practical use of extremely high pressures. He proved that there is but little more difficulty in exerting a pressure upon gases of 1,000 kg. per sq. cm. than one of 100 kg. We quote the following paragraphs from the *Comptes Rendus* of the French Academy.

It is a well-known fact that modern science and industry make extensive use of high pressures. Applications of this force are useful in the refrigerating industry, in the liquefaction of gases or their compression, in furnishing motor power, in the artillery, in submarine operations, and in many chemical reactions, or to solve various mechanical and physical problems. It is, therefore, of the greatest possible interest to know whether so valuable a resource is already exploited to its full possible extent, or whether, on the contrary, we may look for improvements in this line.

The artillery makes use of pressures of from 2,000 to 3,000 atmospheres and certain physical investigations, like the magnificent researches of Tammann and of Bridgman have extended such pressure to what is at present the extreme limit of 11,000 atm. But in these cases the employment of high pressure is essentially discontinuous and for infinitely short periods of time, or else the pressure exerted is in some sort static and operates upon an extremely reduced scale.

As a matter of fact most industries make use of hardly more than 20 to 30 atm.; and when the industry of compressed gases or (with Linde) that of the liquefaction of air was obliged to contemplate the production and daily utilization of large masses of gas under a pressure of from 150 to 200 atm., this was thought such an enormous increase that it was estimated that such pressures would be almost impossible to exceed. This opinion is still very generally held and it is not without interest to point out that when the "Badische Anilin" Company was obliged to explain to our commanding officers the stupendous installation of the Haber process made by them in their factory at Oppau, they did not fail to lay great stress upon the difficulties which they had been obliged to overcome, such for example, as these involved in the daily compression of large masses of hydrogen at 200 atm. I wish to establish the fact here that this idea is quite unjustified; not only is there no real difficulty in compressing gases at much higher pressures but the most ordinary common sense is sufficient to show that it is both easier as well as more advantageous to make use of a pressure of 1,000 atm., for example, than of one of 100 atm. . . . It is a well-known fact that leather collars, those useful accessories in the production of pressure, function all the better the higher the pressure is. I have been able to demonstrate that this efficacy of the leather collars of compressors is not compromised by pressures very much higher than those which it has heretofore been the custom to make use of, and their utilization which has been made feasible by a few simple precautions has enabled me to obtain by the aid of simple pistons compressors whose power, increasing progressively, has exerted a pressure of 1,000 atm. upon more than 100 cubic meters of gas per hour.

It may be observed that a compression installation with a capacity of 1,000 atm. differs from a corresponding installation with a 200 atm. capacity, merely by the addition of one or two very small cylinders, and that the law of isothermic compressions stating that the work done increases evidently merely according to the logarithms of the pressures, requires only three cylinders to compress at 1,000 atm. a substance which already required two cylinders to compress it at 100 atm.

In order to apply such pressures it may be remarked that the difficult thing is evidently not the construction in the apparatus which produce or employ them of walls sufficiently thick to safely resist such pressures. The only really difficult thing is to make the joints tight enough. But it must be remembered that no matter whether the pressure is 100 atm. or 1,000 the joints must be perfectly tight, since the smallest leak entails losses which cannot be allowed.

Furthermore it is easier to make a tight joint for 1,000 atm. than for 100, for with an equal yield of gas at a given power of installation the joint is much smaller because of the enormous reduction in the volume of the apparatus.

This opinion is entirely justified by the facts and I was able to prove to MM. D'Arsonval and Le Chatelier as early as 1917 that experimental compressing apparatus comprising numbers of joints, stop cocks, etc., can be manipulated with the greatest ease. This apparatus when charged with a 1,000 atm. and immersed in water did not allow the slightest bubble of gas to escape.

There is no doubt, therefore, that since such important advantages, thermo-dynamic and other, can be made available by very high pressures, when any given special problem requires such pressures, there should be no hesitation in having recourse to them.

USING HIGH PRESSURES IN MAKING SYNTHETIC AMMONIA.

But M. Claude was not content with demonstrating the general advantages of high pressures. In subsequent experiments he undertook to prove the value of such pressures in the synthetic manufacture of ammonia. His report upon the subject was presented by the well-known scientist M. d'Arsonval, at the session of the French Academy of Sciences held January 12, 1920. Because of the practical as well as theoretic interest of the subject we here present his remarks in full:

The German method of the direct synthesis of ammonia has proved that a pressure of 200 atm. is sufficient to insure in practice the complete combination of the gases taking part in the reaction. It may seem unreasonable, therefore, to employ a pressure of 1,000 atm. instead of 200 atm., since this increases the labor of compression, taking into account the steadily augmenting diminution of compressibility, in the approximate ratio of 3.5 to 2.3.

It is my purpose here to set forth the reasons which largely justify, however, the theoretical additional expense, but with the reservation that the practical applications required to support the theory still lie in the future.

To begin with in order to secure with a pressure of only 200 atm. the combination of 80 to 90 per cent of the reacting gases, the latter must be repeatedly passed over the catalyzer, and after each passage the ammonia formed must be separated out, since only 10 or 12 per cent of the remainder enters into combination at each passage.

With a pressure of 1,000 atm. on the contrary three passages of the gases over the catalyzer may suffice, and for a given yield the required volume of the catalyzing apparatus is reduced much more than in the inverse ratio of the two pressures, to no more than a *tenth* at most, in fact, and this circumstance of course, entails very important savings with respect to original cost, to labor, and to the expense of installation. Furthermore, by reason of the enormous increase in the factor of combination a much greater amount of heat is liberated per each kilogram of the reacting mixture, and this, too, in a much smaller volume. Because of this *auto-reaction* is secured an apparatus of very low power, and so much heat is disengaged, indeed, that it may be relied upon to furnish a good part of the motor power, in the form of superheated steam, and it should be noted particularly, since auto-reaction has hitherto been attainable only with huge apparatus combined with exchanges of very effective temperatures, that by employing super-pressures it is possible to make use of much

smaller units—and this will render it possible to utilize upon the spot the hydrogen which is a by-product of various existing industries.

In the second place the use of super-pressures renders it very easy to remove the ammonia after each partial catalysis.

I have stated that at 1,000 atm. it is easy to obtain in practice contents of ammonia equal to 25 per cent, or, when hot, a pressure equal to 25 atm. of ammonia. Since the maximum tension of this substance at 15°C. is only 7 atm. it is evident that the *mere cooling by water* of the mixture of reagents at its exit from the catalyzing tube will suffice to liquefy nearly the total amount of the ammonia—in spite of the fact that the latter is less easily condensed when contained in the mixture than when by itself, and of the circumstance that the gaseous residue (which is reduced, furthermore, to 60 per cent of the initial gas) carries with it about 2.5 per cent of the ammonia, one can thus condense after each passage more than 90 per cent of the ammonia formed.

Under the conditions established in Germany on the contrary, i.e., a pressure of 200 atm. and 6 per cent ammonia, the pressure proper to the ammonia is only 12 atm. and there can be no question of condensation by means of cold water alone, which would fail to liquefy more than half of the ammonia formed. It is necessary to do one of two things—either to reduce the entire quantity of the gaseous mixture, containing a very small amount of ammonia, to a temperature at which the tension of the latter is very low, not more than 40°C. at most, which can be done only by the aid of expensive refrigerating apparatus, or else to remove the ammonia *by dissolving it in water* injected at a pressure of 200 atm. The first process has been abandoned, having been found too costly even with exchangers having a very effective temperature, while as for the second process, aside from the very considerable labor involved in the introduction of the water, the process is very complicated because of the motors, pumps, column dissolvers, etc., it requires.

The method of employing super-pressures is free from these objections and, furthermore, it has another advantage in the circumstance that the ammonia is recovered in a liquefied form and not in an aqueous solution.

I have already explained elsewhere (vide the *Comptes Rendus* of the French Academy of Sciences, Vol. 168, 1919, p. 1101) how the rational transformation of ammonia into fertilizer ought to be effected not by means of the costly sulphuric acid but by the aid of the chlorine which is at present lost as a by-product in the Solvay soda industry. By this means, too, enormous quantities of sodium carbonate are obtained as a sort of by-product. A closer study of this question has led to an adaptation of the Schreib process in which the expensive evaporation of large masses of solutions is replaced by *alternate precipitations* of CO_3NaH and NH_4Cl, the latter being rendered possible . . . by the insolubility of the NH_4Cl in the *neutral* solutions of ammonium carbonate, at an approximate temperature of 5°C. This process, which avoids, furthermore, the loss of large quantities of non-decomposed sea salt which is thrown down at the same time as the $CaCl_2$ in the present Solvay process, requires, therefore, a large amount of *cold*. This cold is produced directly by the mere evaporation of the liquid ammonia and in amounts which are almost sufficient in themselves by reason of the 300 frigories per kilogram, whereas synthesis with a pressure of only 200 atm. must obtain all this cold, other things being equal, by a very considerable extra expenditure of energy. The liquid form in which the ammonia is obtained by means of the super-pressure process saves, therefore, a large portion of the excess energy expended in this process.

It should be remarked, moreover, that the principle of the alternate precipitations of NH_4Cl and of CO_3NaH in the same liquid requires that the *ammonia* should be delivered *in the gaseous form*, as well as the carbon dioxide. Hence the ammoniacal solution obtained in the German process, which must be distilled in order to vaporize and rectify the ammonia, necessitates expenditure of heat, a complication from which the super-pressure process is free.

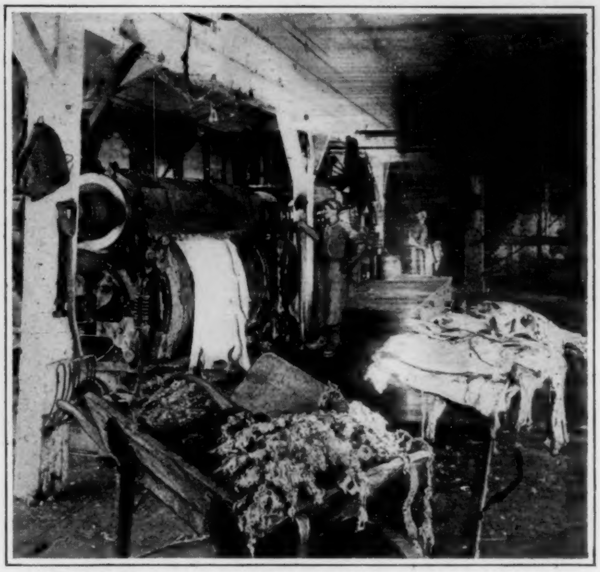
Finally, I will point out another important difference. In the German process as I have said, above, the low factor of combination makes it necessary to repeat the passage of the gases over the catalyzer a great many times; in order to do this it is necessary to raise the pressure of the gases which have traversed the system by an amount equal to the loss of pressure which they have undergone, in other words, by from 10 to 20 atm. Since these passages of the mixture of gases over the catalyzer are very numerous the corresponding expenditure of energy amounts to more than one-tenth of the initial energy of compression, and the pumps required for the recompression constitute a fresh complication. These two inconveniences are avoided in the super-pressure process because of the greater magnitude of the factor of combination, the facility with which the ammonia is abstracted, and the possibility of attaining an auto-reaction with a very slight gaseous expenditure, it is only necessary in this process to cause the gas to traverse a very small number of catalyzing apparatus *successively*, abstracting the ammonia after the passage through each, which is obviously quite possible without any raising of the pressure; furthermore, this process permits the continuous elimination of inert gases such as argon.

If we attempt to calculate all the ways of economizing energy made possible by this new process, we find that it is not only superior in all probability as respects the cost of installation as well as in its simplicity and the possibility of employing small units, but also, perhaps, as regards the special consumption of energy.

RÔLE OF ZINC IN THE HUMAN BODY.

RECENT researches made by Prof. Delezenne at the Pasteur Institute in Paris set forth the important part which is played by zinc in the functions of the human organism. The question was brought up in the first place by a series of researches upon the venom of serpents, this work being still going on with fruitful results, but in the meantime he was led to observe that zinc occupies a place of the first importaace in the animal economy, and especially as concerns the cells which constitute the same. In the first place he found that contrary to what was believed hitherto, the metal zinc is an essential and permanent constituent of the substance of tissues and organs, and in fact this metal exists in all organs, although in a rather small percentage, or about 0.0001 by weight, which is variable according to the character of the organs. The highest proportion is found in the nervous centers, for instance the brain or the tymus. As to what was the special rôle or the proper function of the metal in the working of the organs of the body, he was led to seek the solution by referring to his researches on the venomous substances of serpents, for these had shown him that zinc always existed in a considerable proportion, up to 0.6 per cent, in the venomous substances, and what is remarkable is that these poisonous substances are usually more active as they contain a greater amount of the metal in their composition. It is also found that the properties which are peculiar to zinc are connected with the special form of the chemical combination which contains the zinc in the venomous substances. This is analogous to what is observed for instance in the case of potassium, which is toxic in cyanide of potassium and non-toxic in the chloride and other salts of this metal. In any case, it appears to be demonstrated that the property possessed by the animal poisons of decomposing the cells or of partially decomposing the nucleic acids which are the fundamental constituents of the cells, is connected with the presence of zinc. Then when it is remembered that the metabolism of the cells, or the totality of the chemical operations of nutrition, is also connected with the transformation of the nucleic acids, it is to be concluded that zinc is very probably one of the most essential agents in the growth of the human body.

THE "BEAMING" PROCESS, WHICH CONSISTS OF SCRAPING HAIR OFF THE SKINS



REMOVING HAIR BY MACHINE AFTER THE SKINS HAVE COME FROM THE SWEATING VAULTS

Leather—A Product That Is Still a Mystery

Process of Tanning Hides

By Robert G. Skerrett

Photographs copyrighted by Keystone View Company

If all steel looked alike to the bridge builder we should have catastrophes in plenty. And just because all leather is simply leather to the vast run of shoemakers the public pays not only dearly for its footwear but suffers physically, yes mortally, therefor. But don't let us anticipate. We shall come to the evil of this attitude in time. In the meanwhile let us try to describe an industrial paradox.

The dictionary tells us that leather is the skin of an animal, or some part of such skin, tanned, tawed, or otherwise dressed for use. And recourse to a whole library of lexicons is unlikely to prove more definitely revealing. In fact, we have it on most excellent authority that leather is leather; and exactly why this is so still has the scientific world guessing. True, the chemist is alive to the fact that tannin works the unexplained transformation; but what tannin is persists in remaining pretty much of a mystery, although the technicists know where to get it and can certainly identify its presence by reactions induced when associated with salt and gelatin.

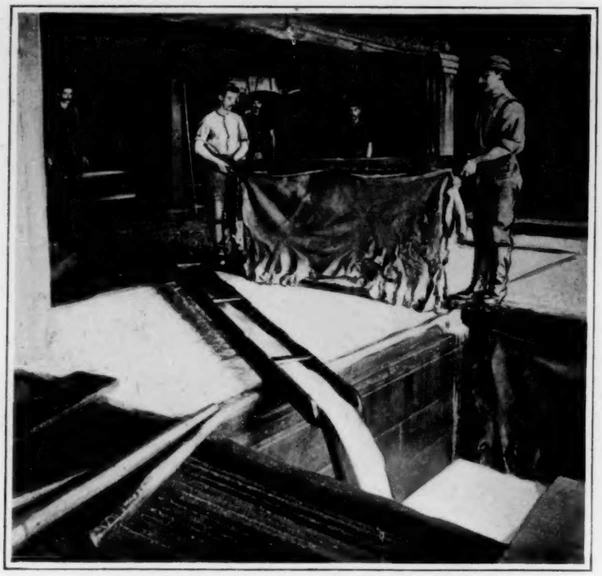
It will probably surprise no one to be told that the latest theory having to do with the art of tanning is that the change wrought in the skin is due to an electrical attraction set up between the hide fiber and the tanning liquid, because year by year we are discovering more and more of electricity's manifold activities in this mundane existence of ours. Professor Henry R. Procter, of the University of Leeds, England, is now confident that the complex substance commonly known as leather is the product of the co-precipitation of hide and tannin resulting from the electrical phenomenon just described. Eventually, this pronouncement may have its helpful effect upon an industry which is undeniably of a groping character today.

The general public has every reason to be interested in the broad topic of the making of leather, because the matter eventually touches everyone's purse and, in a large measure, his pride, as well. Indeed, it is probably no exaggeration to say that the health of millions hinges upon the character of the material worked into their common footwear. Without going into technicalities, it will answer our purpose to know that the skins of vertebrate creatures—mammals, for instance—are composed of four layers or membranes. The outer one consists of the epidermis, which carries the hair; the second one contains the nerves, the smaller blood vessels, etc.; the third, or middle portion, is the dermis or true skin made up of fibers interwoven and intersecting in every direction, and the fourth, or innermost, is the fat-bearing tissue immediately overlying the flesh. It is the true skin or dermis which forms the basis for leather.

The tanner seeks primarily to fit the skin for leather making by getting rid of the hair and those portions of the skin that are liable to putrefaction; and with these ends achieved he has left the fibrous texture or layer which is transformed by tanning into the material used in the manufacture of boots and shoes, bags, harness, belting, gloves, etc. The nature of the ultimate product depending, of course, upon the kind of hide or skin utilized and the processes employed during its treatment at the tannery.

Here in the United States we use the hides of horses, steers, cows, calves, pigs, goats and sheep, not to mention such imported materials as the hides of the buffalo and the llama. In some parts of the world, from which we get "stock" for tanning, the hides are simply air dried in the sun, while sheep skins are shipped to us from Australia and New Zealand after they have been pickled by means of a salt solution to which sulphuric acid has been added. Hides of native origin, however, are generally preserved for the time being by salting, and reach the tanner in a damp condition, carrying all of the salt they will absorb. Because of this fact the tanner knows just what he is getting when he buys the hides by weight; and this is the usual practice.

No matter what may be the kind of leather into which hides are to be worked by subsequent tanning, all of them have to be soaked to soften them as a preparatory process. For this purpose clean and soft water is desired; and if the water be hard it is made soft by a suitable amount of borax. The



VATS USED IN THE TANNING OF HIDES

OILING HIDES TO PRODUCE FLEXIBILITY

soaking also serves to remove salt, dirt and blood adhering to the hides. Care has to be taken that the hides while thus being softened do not become flaccid. If soaked too long, the hides lose gelatin and make loose or spongy leather. The soaking is in two stages each of twenty-four hours. Lack of caution during the soaking may produce a "pricked and pitted" grain—"grain" being the natural outer surface texture of the leather. Hides that have been dried have to be milled or worked after soaking in order to assure a satisfactory limpness so that they will later on permit the tanning liquor thoroughly to penetrate the fibrous mass. In a dry hide the intermingled fibers are closely cemented together, and the aim is to break down this bond in tanning without injuring the network upon which the final flexibility of the leather depends.

Following their soaking, the hides are subjected to liming by being placed in vats filled with a solution of slacked lime. To this bath is added a percentage of sulphide of sodium. There are six of these successive liming periods, each of twenty-four hours' duration—the hides being taken out of the preceding bath before being put into the next one which differs somewhat in strength and composition. According to the character of the raw product, the liming operations take anywhere from three to ten days. After passing through the last vat, the hides are reeled into warm water, where they remain two or three hours. The immediate effect of the lime is to swell the fibers of the skin and thus to split them up into their constituent fibrils.

Because the upper layer of skin has been dissolved or loosened by the lime the hair can be readily removed by placing the hides upon "beams" or slightly rounded slanting boards and scraping the exposed surface by means of a dull metal instrument. The choicest grades of hair are later on sold to plasterers, and the white hair is not infrequently used in the manufacture of so-called all-wool cloths. Having disposed of the objectionable hair—and it is essential to get rid of all of this if the leather is to be finished on the grain—then the next step is that of deliming. This may be preceded, however, by splitting the hides or cutting them into "sides." Deliming is accomplished in two ways—by an acid bath or by recourse to bacterial bathing—the latter being done by animal manure. Artificial baths are widely employed at the present time, and these are composed in the main of ammonium chloride and pancreas. Bran drenching is another way of neutralizing the lime, and all of these processes tend to make the hide pliable. The extent to which the treatment is carried is contingent upon the kind of leather which is to be produced.

Once more the hides must be washed thoroughly with clean warm water. This is very essential to insure a good clear grain which will color evenly. It is then customary to put the hides over horses to drain, and it is not unusual to subject them to pressure to free them of some of the remaining water before starting the actual tanning. Tannin for this purpose comes from many sources, but most of these are of a vegetable nature.* Their net effect is to separate the hide fibers, hold them so, and to make the animal material nonputrescible. Years ago hemlock and oak barks furnished much of our needed tannin, and the leathers so obtained were known, respectively, as hemlock and oak leathers. When the leather was the outcome of tanning successively with oak and hemlock liquors the product was termed by the trade "union" leather. Today, union leather

PLACING HIDES IN THE OILING DRUM

*See article on Synthetic Tannins in SCIENTIFIC AMERICAN MONTHLY, April 1920, pp. 326-330.

is the result of treatment with any kind of tannin that can be had in the market. Tannin from chestnut bark is now employed extensively in turning out heavy leathers; and largely because of the war and the need to make ourselves as self-sufficient as possible in raw materials, it has been found practicable to secure an excellent tannin from the bark of both the white and the black spruce. For the lighter leathers the leaves of the sumac, which contain between 20 and 30 per cent of tannin, are a source of supply.

THE PROCESS OF IRONING THE LEATHER

Without going into details, the tanning procedure consists in putting the hides, stage by stage, in tanning liquors of increasing strength and agitating the hides the while by moving them in one direction while the liquid bath travels oppositely. Gradually the solution penetrates the hide—sole leather, naturally, taking longer to accomplish this than the lighter materials. By carrying the tanning process to the point of complete penetration the resulting sole leather, for example, is a firm and heavy product. In the days gone, it took quite two years to convert the "green" hide into marketable leather, but now the tanner thinks he is doing quite enough if he devote five months in reaching this stage.

This is not hard to understand, as an expert has explained it, if we bear in mind that hides bring quite twenty cents a pound wet salted, and a sizable tannery puts in treatment anywhere from 10,000 to 50,000 pounds every twenty-four hours. Because of the capital thus invested the tanner is anxious to realize on his investment as soon as possible, and this economic side of the industry has its reflex in the grade and the wearing quality of the leather worked into our shoes. This effort to speed up is evidenced in what is known as the drum-tannage method. By that process hides are placed in a revolving drum carrying a comparatively small quantity of the tanning liquor, and this is strengthened rapidly as the hides are agitated. It is said that tanning can be accomplished in this way in a week's time; and the resulting leather is very satisfactory so far as appearances are concerned. The material, however, does not show up well in service in the matter of keeping out water. The reason for this is that the tanning liquor has not time enough in which to fill the hide substance with the insoluble matter, technically termed "blooms," which, in the more leisurely prepared leathers serves to hold the water at bay. Shoes made from drum leather are essentially for dry-weather wear. The only trouble is the buyer seldom, if ever, knows this.

When sole leather has been duly tanned it is customary to subject it to a filling process which is called in the trade "fat liquoring." As may be readily understood, this liquor is composed of oils, grease, and soaps of one kind or another. The fat liquor, with the leather, is placed in a heated drum, and the latter is revolved for the better part of three-quarters of an hour, during which time the leather absorbs the oleaginous mixture and the while gets rid of any water that may have been stored in its substance. The leather is next removed from the drum, placed on horses, and allowed to drain

BLACKING THE LEATHER AND PUTTING ON THE FINISHING TOUCHES

for twenty-four hours. Following this the hides are "struck out," i.e., stretched on each side with a tool, oiled on the grain, and then hung up to dry. During drying the temperature should be at about 80 degrees Fahrenheit; and it is necessary to insure a good circulation of air so that the leather will not dry too rapidly and thus acquire a parched appearance.

Where leather is tanned by the chrome process, which is used in this country in the making of about 90 per cent of the material employed in the manufacture of uppers for men's shoes, the tanning liquor is composed of a solution of basic sulphate or chloride of chromium. The salts thus entering the hide cling fast to the fiber and will subsequently resist washing with water—the leather will even stand boiling. Chrome leather while not as good as that produced by the use of vegetable tannins is, nevertheless, of excellent quality when care is taken in the selection of the material and due heed is exercised during the processing.

A combination of regular tannage and chrome tannage—either preceding or following the other—yields a leather of a high grade which will have the wearing qualities of chrome leather but will not slip on a wet pavement like the latter. This leather retains its flexibility and is strongly resistant to water. This double treatment requires that each tannage shall penetrate the leather through and through. The reason why more hides are not so dealt with is because of the much higher costs involved. When leathers needing coloring have been duly dyed and, possibly greased, they are permitted to dry to a suitable degree and are finally surfaced by means of rollers, frequently made of glass, operating upon a pendulum-like arm, which impart a polish.

Curiously, the shoe manufacturer does not concern himself about the possible adulterations which go into the tanning processes. He seldom, if ever, analyzes sole leather, for example, to discover if there is any undesirable matter stored away in the product. The one thing that he is fussy about is that the leather shall have the desired color—something that in no wise indicates the wearing or other essential physical qualities of the substance. The net result of this attitude is that the manufacturer of shoes is principally bent upon appealing to the eye of the retailer and the ultimate consumer; and the latter is generally unable to safeguard himself against deficient quality. He does not even realize what the manufacturer's indifference means when his shoes wear out quickly; the more money he spends in footwear the more the industry profits.

It is an established fact that the modern art of tanning falls a long way short of the standards set when the relatively primitive methods of making leather prevailed. Books bound a hundred years and more ago with leather of those days are still in good condition, while modern bindings of leather are very apt to go to pieces after a score or so of years. The urge of haste has not yet been offset by anything that the chemist has been able to evolve for the purpose of speeding up the transformation that takes place in the hide in turning the material into leather. Indeed, the outstanding shortcoming of the art is a fairly general absence of positive standards by which the several processes can be gaged and their respective products graded.

In a very able paper read before the American Chemical Society by Dr. Lloyd Balderston, that eminent expert laid a great deal of stress upon this aspect of the subject of the treatment and manufacture of leather. And at that time Dr. Balderston said, in effect, that it was the hope of Professor Procter and his co-workers at Leeds, by establishing the electro-chemical nature of tannins, to make it possible thus to foretell the character of leathers to be obtained from different materials and mixtures.

America is not only the greatest shoe-manufacturing nation, but our people utilize in other ways enormous amounts of leather. The tanning industry, therefore, is one of our biggest and most important activities. In normal times we amplify our own raw supplies by importing anywhere from 600,000,000 to something like 800,000,000 pounds of hides, and it is self-evident that the question of properly converting this material into really satisfactory leather is a matter of the utmost economic moment. The problem of the chemist is now to find processes by which the hide can be transformed in the shortest practicable time into leathers possessing all of the endurance and other desirable qualities which used to characterize the output of the tanneries of decades gone. The chemist will undoubtedly be able to open the path to this goal when he determines beyond peradventure just what leather really is.

Something About Artificial Silk*

Present Production and Possible Sources of Future Supply

PERHAPS no other textile fiber at the present time absorbs so much attention of the financial and the industrial world as artificial silk.

Financiers, both here and abroad, are busy with the shares of the existing and prospective countries manufacturing artificial silk under various trade or descriptive names and according to the several processes already known as successful, and high hopes are entertained for the future of artificial silk, which for some time past has been established as a staple product. On the industrial side optimism is also the predominating view of the situation, by reason of the almost daily increasing number of articles in which artificial silk is associated, and by reason of the insufficiency of the supply of natural silk to meet the requirements of the consumers and the manufacturers. Also because fabric manufacturers have obtained with artificial silk, used in connection with natural fibers, effects and fabrics not possible even by the use of natural silk. One such effect is high luster, and the other is a "hand" that no other material but the artificial fiber can impart to the goods. And by the same token, the fiber gives an apparent added value to the finished material more through its appeal to the lust of the eye than from intrinsic worth.

This is not so paradoxical as it might at first seem since the high cost of artificial silk in itself contributes to meeting the luxurious demands of the present uncertain period. It has now secured a very important position in the textile industries, in no branch of which does it occupy so much a position of importance as it holds in the silk industry. It may, therefore, not be out of place to refer here to some of the unfamiliar history of this product.

The name artificial silk first appeared in patent literature in 1855, when Audemars, of Lausanne, described a method of preparing vegetable fiber solely for the purpose of use in incandescent lamps. In 1844 Count Chardonnet prepared a fiber from collodion which was expected to compete with natural silk. It was, however, not until 1895 that he was able to offer a denitrated fiber. In 1900 the Fremery and Urban patent for the production of cupro-ammonia collodion was exploited, and in 1903 there came into evidence a novelty which represented the last word in the industry of making artificial silk. The Cross and Bevan patent, taken out in England in 1892, and in France in 1893, concerned the means

*From *American Silk Journal*, April, 1920.

of preparing a thick viscous liquid, called viscose, intended for the purpose of brightening fabrics, which was subsequently so perfected that it was possible to spin yarns from the viscous liquid, and quite a large industry has been built on it since then, so large that extensive plants operating on this system have long been established in many of the European countries and in the United States, and is today practically in control as the world's largest distributers of viscose.

Up to 1903 the new industry, interesting though it was, was not seriously regarded in the industrial world, but was rather considered in the light of an interesting novelty. In that year, however, the Société de la Viscose put on the market the artificial silk which until recently has been the last word in artificial textiles. It may here be noted that this company is, in fact, the monopoly and controls both the European and American markets very effectively, selling or withholding its goods as it sees fit; and only now has the widespread demand for chemical textiles encouraged lesser companies to undertake the manufacture of artificial silks.

As the raw material for the production of viscose is wood, the industry is one which can be established in any climate. Indeed, today the industry, operating in one process or another, is established in the United States, Belgium, Switzerland, Hungary, Poland, Italy, Germany, Russia, England and Japan. In Germany alone, it is estimated that the production of artificial silk was, just before the war, 5,000 kilos daily, and in France, 4,000 kilos.

It is very apparent, however, that the increase in favor of the vegetable fiber coincides definitely with the increase that has taken place in the production of natural silk. In 1914, 19,000,000 kg. of natural silk was produced; in 1906, 23,000,000 kg.; in 1912, 27,000,000; in 1914, 22,000,000; and in 1918, approximately 25,000,000 kg. Yet, for some time past, and at present, there is always a scarcity of silks on the markets, and when it can be got, prices are high, which are features which go to prove most definitely that natural silks are sought after more than ever. That indicates the probability of the belief that natural silk has nothing really to fear from artificial silk as a competitor.

At Lyon, a renewed impetus was recently given to the use of chemical textiles by the invention of an entirely new process, the product of which is called silk cellulose. This new form of cloth is claimed to possess a brilliancy comparable to silk schappe, a remarkable solidity and durability, a touch similar to silk, and absolute imperviousness to water; at the same time it is no more endangered by fire than the ordinary natural silks. While the thread of the viscose silks is, of necessity, relatively coarse and thick, the new silk permits of making threads of considerable fineness, and is particularly remarkable for the quality of the velvets which can be made from it. The new process differs radically from the old processes. Instead of converting a thick liquid (the viscose) into thread, it appears that it is possible to preserve the wood fibers and convert them into a brilliant and solid cellulose. As a result of this, there is obtained a greater molecular concentration and a regular geometric form in the elements that make up the thread; all of which, it is claimed, greatly increases the strength and durability of the cloth.

A large factory for the production of the new textile is being projected for large-scale commercial production in the Lyon district, where such materials as velvets, jerseys, satins, draperies, linings, and other silk goods will be woven. It is as yet quite impossible to state, with any exactness, the price at which the silk cellulose will appear on the market. Although artificial silks can already be obtained at very advantageous prices as compared to natural silk, the inventor of the new process claims that his product will be able to cut still further the cost of chemically produced threads.

Despite the fact that for years to come the artificial textile may not compete with natural silk, yet the producers of the latter must eventually look for advances and inventions on the part of chemists that may ultimately remove the defects now so obvious in the viscose silks. What is most needed is ability to spin a much finer thread, which is at present extremely difficult to do on account of the air which is held in the coagulating bath in which the artificial threads are formed. In seven or eight years, when there has been time for a surplus of artificial silk to accumulate on the market, due to the establishment of new plants and increased production of other textiles, those whose interests are bound up in the artificial silk industry will be forced to bring about new developments in order to enable it to hold its place; at that time real competition may be looked for between natural and artificial silks.

The French weavers of vegetable thread, because of the difficulty they experience in obtaining sufficient quantities of that kind of thread, motivated, not long ago, a demand for the reduction of the import duty on that maerial, which is now 15 francs ($2.895) and up per kg. (2.2 pounds), including the recent increases. The lowering of the duty was, however, considered hardly justified, it being taken into consideration that at the last meeting of the Belgian Tubize Silk Association it was announced that America would absorb 20,000 kg. (44,080 pounds) per day, if that amount could be produced, in spite of the entry duty of 35 per cent ad valorem. The prevailing opinion is that the barrier of fifteen francs does not appear to be of a nature to hinder importation into France at the present time, in view of the fact that the French production must be stretched to its greatest extent in order to satisfy the needs of the home market, which is turning a deaf ear to sales orders from abroad.

From the foregoing it will be seen that whereas not so many years ago artificial silk was tabooed in the silk trade, it has since found a position of its own in the industry, and its wonderful success today shows there is ample room for both fibers, and now, instead of the name "artificial silk" being an appellation damaging to the interests of the silk industry, it really serves the purpose, by contrast, of eulogizing the many intrinsic merits of natural silk.

THE LENGTH OF WOOD FIBERS.

THE current supposition that each species of wood has a characteristic fiber length is not borne out by the many thousand measurements which have been made at the Forest Products Laboratory on wood fibers. These measurements show that a greater difference may be found in one tree than exists between the average fiber lengths of different species. In one Douglas fir disk, for example, the fibers varied from .8 to 7.65 millimeters (.03 to .3 inches) in length, which is a variation of nearly 7 millimeters. On the other hand, the averages of several thousand measurements on Douglas fir and longleaf pine were less than one millimeter apart, being 4.41 and 3.67 millimeters, respectively.

In the first case, 67 per cent of the fiber measurements in one tree fell between 4.5 and 6.5 millimeters, which roughly indicates the meaning of the common term "average fiber length" for the tree or species.

Such data obviously can be of little value for identification purposes, because of the overlapping of the ranges of fiber length in the various species.

Some relations have been observed between the length of fibers and their position in the tree. During the first 20-50 years of growth, the increase in fiber length from the center of a tree outward in any plane is very striking. An approximate maximum having been attained, fiber length, though it may fluctuate somewhat, does not radically change thereafter, even in trees 400 or more years old. Some increase in fiber length occurs also for about two-thirds of the distance from the butt to the top. Within each annual ring the length of the fibers varies, particularly in the conifers, where the early springwood has the longest elements, and the last formed cells of summerwood the shortest in the ring.

No clearly defined relation has been found between fiber length and the strength of wood. The longer fibers are often found in the weaker material.

Looking Through the Phonograph Record

Elements That Produce Surface Noise

By Francis F. Lucas

SOME years ago, when the phonograph was in its earlier stages of development, vaudeville performers often entertained their audiences with imitations of phonographic reproduction. All of the then characteristic tinny sounds with the usual accompaniment of scratching and snapping were more or less realistically imitated and the performances were quite apt to end with the repetition of a few sounds, indicative of the stylus traveling round and round in the same groove. In those days the phonograph was more of a novelty than it was a musical instrument, but the tremendous development which followed has made it one of the most popular of musical instruments.

As an entertainer it probably has no equal and has been the means of bringing music and entertainment to the most remote places. During the war we read of the sub-sea raiders lying quietly on the ocean bed while their crews listened to the latest in popular music on the phonograph. All of which goes to show that some really remarkable improvements must have been made, otherwise the demand for phonographs would have died out with the novelty. With the incentive of popular demand it is reasonable to expect that the development of the future will result in more faithful reproduction and greater clarity of tone with the elimination of all extraneous noises.

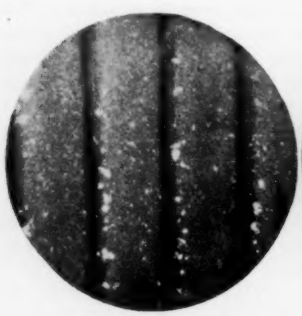
Recently a laboratory study of the standard phonograph records was undertaken with the object of comparing the different record surfaces so that the structural elements producing surface noise might be made more tangible and perhaps, thereby, facilitate the application of corrective measures.

Surface noise or "scratching" of phonograph records is one of the peculiar characteristics of phonographic reproduction which, no doubt, everyone would like to see done away with. It results from contact of stylus and record and has several contributing causes, one of which is the character of the record surface.

To the unaided eye the surface of a record appears exceptionally smooth and highly polished but when played all records produce surface noise. If one were analytically inclined he probably would conclude that even though the record surface does appear smooth and polished it must have miniature hills and dales and be more or less granular. Even with the aid of a microscope and using methods which are usually applied when examining opaque objects the results are not satisfactory.

For the benefit of those who have not had actual experience in technical microscopy it may not be amiss to say that the mounting of objects for microscopic examination is somewhat of an art in itself and that the mode of procedure differs with the character of the specimen. In some cases the specimen is mounted as an opaque object and oftentimes its surface is etched with some reagent which will differentiate in the structure. In other cases very thin and transparent sections of the object are mounted in a suitable medium on a glass slide and protected above by a thin piece of glass called a cover glass.

For critical examination of a phonograph record by microscopic methods the conditions seemed to call for a very thin section from the record surface, a section of the skin so thin that it could be examined under considerable magnification by transmitted light. In making the section the surface of the record should not be disturbed even to the slightest extent, otherwise the true conditions would not be disclosed by the



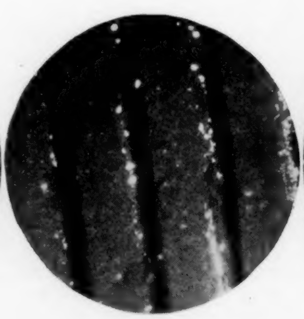
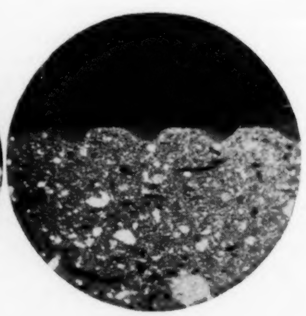



FIG. 1 RECORD A 37 DIAMETERS FIG. 2

FIG. 3 RECORD B 37 DIAMETERS FIG. 4



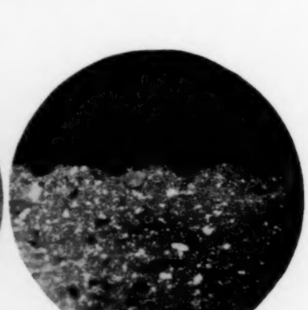
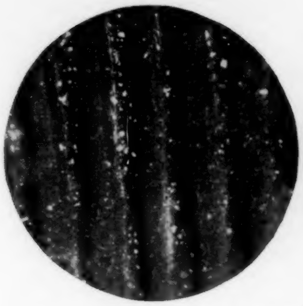



FIG. 5 RECORD C 37 DIAMETERS FIG. 6

FIG. 7 RECORD D 37 DIAMETERS FIG. 8



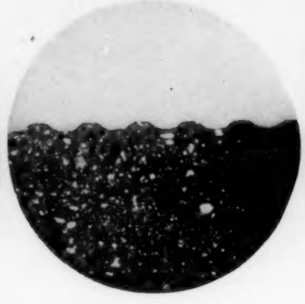
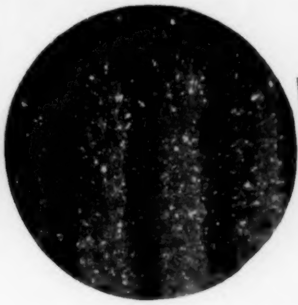


FIG. 9 RECORD E FIG. 10
37 DIAMETERS



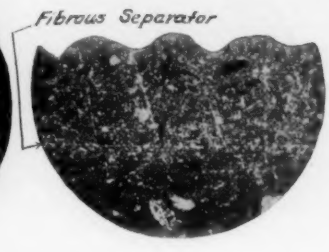


FIG. 11 RECORD F FIG. 12
37 DIAMETERS

subsequent microscopical examination. Moreover, this method of attack would permit the examination of crystalline matter by polarized light and also, it would allow the individual particles to be gaged by micrometry.

After much laboratory work of the most painstaking order and innumerable failures which are usually incident to work of this kind a delicate mode of procedure was developed whereby a section of the surface measuring approximately one centimeter square and only a few thousandths of a millimeter in thickness could be removed from the record. These sections were then mounted on glass slides in the manner described above after which it was possible by means of the microscope "to look through the record" and see the nature and condition of the material forming the bottom of the record grooves. Even to one experienced in technical microscopy the results were startling and they seemed sufficiently convincing to warrant the speculation that the development of the phonograph record has not as yet reached its zenith. As a further aid in the investigation transverse sections also were prepared and a method of reproducing the record surface in a transparent medium was developed as will be described later. To reproduce the surfaces by photomicrography proved somewhat of a problem but by a special arrangement with a powerful illuminant together with the necessary optical system the photomicrographs reproduced here were taken.

In the selection of specimen records for examination every effort was made to secure thoroughly representative records from each manufacturer's product. In general, unused records of the latest production were procured from dealers whose sales are large and by careful selection it was felt that the results would be representative. In those cases where the record manufacturer also markets a phonograph the records were played on a machine of the same make; otherwise they were played on one of the standard available machines adapted to the record. The records selected include all of the standard makes with exception of the cheaper records in which a high degree of artistic or technical attainment should not be expected.

In order that the illustrations may be understood and correctly interpreted a brief description of record construction seems necessary. Phonograph records are made from that class of materials known as hot molded composition. They consist of a binder intimately mixed with suitable mineral and vegetable fillers and a small proportion of coloring matter. Under suitable conditions of temperature and pressure the mixture assumes a plastic condition and may be molded. The binder may be either a natural or synthetic gum or resin, or a combination of both. The commonly used natural resins or gums include shellac and rosin. The synthetic resins (phenolic condensation products) have the property of resisting deformation under moderately elevated temperatures and, too, they produce a very hard surface which resists abrasion. Consequently records made with these resins do not scratch and mar easily during handling. The natural resinous materials are often affected by heat and records made with them are apt to deform unless properly stored. Also the surface of such a record is somewhat soft and apt to be damaged by careless handling. The mineral fibers, such as rottenstone, chalk, etc., are used to impart hardness and strength. The vegetable fillers are usually cotton or wood fibers and their function is to help hold the mass tenaciously together and to counteract brittleness.

Figures 1 to 19 inclusive are photomicrographs of the nine prominent records which were selected for investigation. The bright spots are the particles which transmitted the light more brilliantly than the adjacent particles and from a consideration of the illustrations it seems evident that what to the eye appears to be smooth and polished is actually a rough and rugged road, at least in so far as the stylus is concerned.

From a critical examination of the illustrations one probably would conclude that record "H" should have the least surface noise and this assumption would check exactly with the facts. The record consists of a disk of cheap composition faced with a pure phenolic condensation product. Therefore, the record grooves are made up of a very smooth, hard, homogeneous substance, free from mineral and vegetable matter such as is found in other records. The irregularities shown in Figure 15 were found to consist of small cracks, voids and air bells and

FIG. 13 RECORD G FIG. 14
37 DIAMETERS

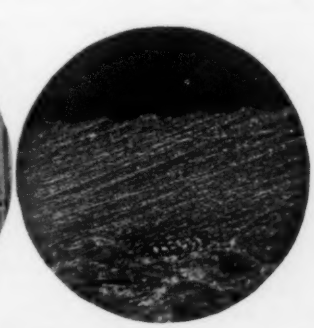


FIG. 15 RECORD H FIG. 16
37 DIAMETERS

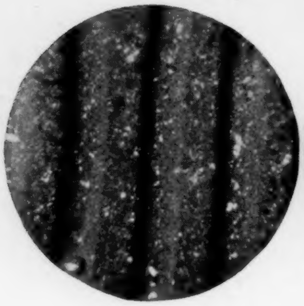
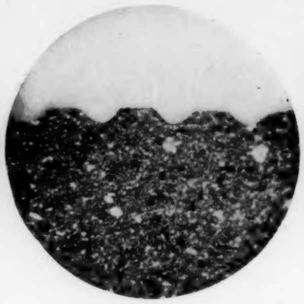
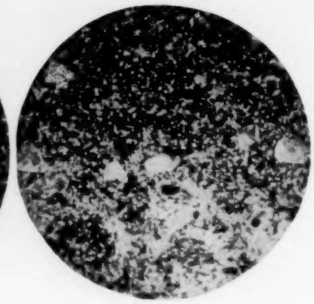



FIG. 17 RECORD I 37 DIAMETERS FIG. 18

TRANSPARENCY 75 DIAM. FIG. 19 RECORD G



37 DIAM. FIG. 20

also of foreign particle inclusions such as dust. This photomicrograph is of special interest because it shows the order of imperfections which commercial molding may be expected to yield when working with a clear homogeneous material. So far as freedom from surface noise is concerned this record left little to be desired but unfortunately the surface coating displayed a tendency to warp and crack; due, apparently, to an inherent physical weakness in the record construction.

On the listening test record "I," Figures 17 and 18, was found to be next in order of freedom from surface noise, although there was quite a gap between it and record "H." In most of the records the surface noise was not especially pronounced and probably would not be objectionable to the average listener except, perhaps, in records reproducing soft music. Figures 17 and 18 show clean-cut molding and quite uniform structure.

In addition to the usual scratching sound, occasional "snaps and cracks" are often heard and these seem to have their origin in a different source. In record "B," Figure 3, certain imperfections in the record surface are to be seen and it seems probable that when the stylus strikes such obstructions as these the reproducer must register some sort of a violent protest. These molding imperfections were found to be more pronounced in this particular record, but they were by no means absent in the other records. Record "B" also had considerable surface noise which one would expect from the nature of the structure as shown by Figures 3 and 4.

Record "F," Figures 11 and 12, illustrates a novelty in construction. In Figure 11 it will be seen that the record body consists of a coarse structure which is faced with a finer composition. Between the body and the surface coating on each side is a fibrous separator. The surface of this record is of finer structure than record "B" and, as might be expected, the surface noise was less intense.

Records "A," "C," "D" and "E" on the listening test were found to be much the same so far as surface noise was concerned. Some differences did exist but it will be seen from the illustrations that the surfaces are inclined to be rough and in some instances the structure is coarse.

As might be expected from Figures 13 and 14 record "G" had the most surface noise of any of the records studied. In some records the scratching assumed very disagreeable proportions and detracted greatly from the musical value of the record. The grooves were found to consist of small and large mineral particles and splintery bundles of wood fiber. The large mineral particles were present in abundance as will be noted and their origin was a mystery until treated by a method of microscopic analysis. Since a large proportion of the record consisted of wood flour it was decided to examine some representative samples of this material. The results showed that the wood flour carried large inclusions of mineral particles similar to those found in the record surface. Following the wood flour to its origin it was found to consist of sawdust ground to fineness in a stone mill. Apparently in this way particles of the grindstones were being conveyed to the record surface. In Figure 22 the coarse and splintery structure of the wood flour is shown by means of a photomicrograph taken by dark ground illumination. A large mineral particle is much in evidence. An idea of the extent to which mineral particles were found to be present in wood flour may be judged from Figure 20 which shows the inorganic matter found in about one per cent of the wood flour which could be heaped on a ten-cent piece. The wisdom of using material of this kind would seem open to serious consideration, especially in view of the fact that chemically separated wood fiber free from foreign inclusions may readily be obtained. Wood fiber of this nature is illustrated in Figure 21. It will be noted that the wood has been reduced to its ultimate fiber, which is the best possible condition for molding plastics.

As a further aid in the investigation a transparent medium which would take an impression from the record surface was developed, the idea being that differences in level would be disclosed by differences in the depth of color of the impression when viewed by transmitted light. That is, a mount of this kind when examined under the miscroscope would constitute a relief map of the record surface. Figure 19 is from an impression taken from record "G" and the similarity of Figures 13 and 19 is quite evident. In Figure 19 the light colored bands are the ridges and the broad darker bands are the grooves from which it is clear that a dark area indicates a depression in the record surface and a light area an elevation. This method of examination has the advantage of being quicker but does not permit qualitative and quantitative analyses by means of the microscope.

From a consideration of the data obtained it would seem that future improvements in surface conditions appear most hopeful along lines which will result in a finer and a more homogeneous structure.

FIG. 21. FIBERS OF WHITE SPRUCE SEPARATED BY CHEMICAL MEANS. ENLARGED 37 DIAMETERS

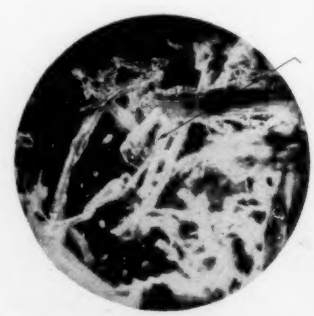


FIG. 22. GROUND WOOD FLOUR WITH COARSE MINERAL PARTICLE INDICATED BY THE ARROW

Progress in the Art of Taking Moving Pictures

Cinematography in Germany

IN a recent number of the German magazine, *Umschau*, Frankfurt-am-Main, Walter Thielemann gives some interesting information about cinematography. He writes: Even during the years of the war there has been much new discovery in invention with respect to the art of the cinematography on the part of the German technologists. Many of these things were stolen by the Allies during the abeyance of patent rights. Those inventors, however, who were clever enough to renounce their patent rights during the war and deferred the publication of their inventions until the coming of peace, are now giving to us a number of new processes in the technique of the cinematograph.

One such invention which promises to be epoch making is the work of a German-Austrian, who during the war discovered a method of preventing the annoying flickering of the pictures during the projection of the films. The flickering of the film projection is caused by the fact that the strip of film is in constant motion while the source of light is steady. This disturbance is remedied by the new invention in the following manner: by a system of movable mirrors the light source accompanies each position of the entire strip of film upon its progress and with the same rate of speed. By means of this arrangement perfectly clear and definite projection images are obtained for every part of a film; the flickering of the film may soon be expected, therefore, to be a thing of the past.

Another invention, "the film opera," works in connection with real singers and in front of the projection surface of the film there is a complete orchestra assisted by living singers. The director of the orchestra is photographed upon the film at the same time that the regular moving picture performers are photographed. The musicians and singers watch his motion and he gives them all the signals that a regular leader of the orchestra would do. At the same time the public can see upon the lower edge of the film the corresponding metronomic signs which exactly correspond with the signals given by the orchestra conductor shown upon the film. Really surprising results have been obtained in this way in the film operettas produced in the last few months. The most melancholy thing about this purely German invention is that by the stealing of patents mentioned above, foreign countries can employ this device to the injury of our own industrial firms.

Among the manifold novelties in the list of cinema apparatus which are especially suited to assist the arts of education, one very new and valuable one is that by means of which the progress of the film may be arrested for a time when desired. Hitherto when the film was stopped its highly inflammable material was almost certain to take fire. The new invention enables the operator to stop the passage of the film by means of merely pressing a button and by pressing a second button it is possible to make it run backwards. Hence, when it is desired to explain and make impressive a specially important part of an educational film, or when the students desire to ask questions about it, the given portion of the film may be held or shown repeatedly as long as the instructor wishes. This novel invention which has already been amply tested, will doubtless give great satisfaction to teachers and lecturers.

The use of films for instruction has made special progress in the last few months, particularly with respect to microscopic moving pictures. Before the war these were exclusively prepared by French film firms. Among these we may mention interesting microscopic moving pictures, taken from life, of the water flea, a crab-like animal scarcely two milimeters long, which is shown enlarged several thousand times. The observer is able to see not only the externally visible motions of the feet, the antennae, etc., of this minute insect, but also the pulsation of its primitive heart sac, the movement of its eyes which contain dark pigment set about with chalk crystals, and even the functioning of the muscles of the eyes, with perfect clearness. Other films exhibit diagrams showing especially the introduction of pathogenic germs into human organs and the resulting sickening of the whole body, as also studies of the life of bees, etc.

A Berlin engineer has succeeded in retaining speech upon a thin sheet of celluloid and has thus solved a difficult problem which countless investigators have worked at for many years, and before which even Edison's skill has recoiled. By the aid of a new recording process it has become possible to replace the heavy phonograph plates, whose material is at the present time both costly and difficult to obtain, by thin, flexible sheets of celluloid about 12 cm. in diameter; the advantage in the employment of these is that they practically do away with the irritating "scraping" accompanying sounds, which ordinarily injure the tone. Since the plates can be replaced by a ribbon the *talking film*, which has been sought for so many years, has at last been discovered. The greatest practical advantage of the new dicovery consists in the great cheapness of the new plates, which will enable the phonograph to be used for the general instruction and entertainment of all classes, and may be expected to be of peculiar service to the men blinded in the war.

Film caricatures, i.e., pictures which appear upon the white screen as if drawn at lightening speed and with skill by the hand of an invisible master, have lately been extremely popular. As soon as the drawing of the pictures has been completed the figures begin to move. To the layman this appears most mysterious. In reality, however, the film caricatures are drawn exactly as shown upon the film except that they are done very slowly instead of very rapidly, the rapid passage of the film giving the illusion. In preparing such pictures the artist first makes a sketch of the proposed work. He then covers the pencil lines of his sketch with white tempera, so that they can still be recognized at very close range. The work is then placed before the camera. The artist draws a line with the dark color and steps aside, whereupon the operator takes a picture of this single line. The artist then makes a second stroke and steps aside once more until the camera has recorded this, and so on till the work is finished. If it is desired to have the figures move, the movable portions are cut out of paper after being drawn and then moved in front of the apparatus. Making such pictures is not only exceedingly difficult, but demands the most exact precision. However, a surprising degree of perfection in their preparation has been attained during the last few years.

STERLING SILVER.

The Engineer (English), October 10th, publishes the paper of Smith and Turner on "The Properties of Standard or Sterling Silver." This silver derives its name from the fact that it has been the legal standard alloy for all British silver coinage and silver plate. It contains 92.5 per cent silver and is the only silver alloy of any industrial importance. The authors found that the temperature of the metal in the crucible should be about 1200° Centigrade when ready for casting, and that the stream of silver during pouring was about 1113° Centigrade. When casting the alloy precautions must be taken to secure homogenous composition throughout the ingot for there is a tendency for the silver to become concentrated at the center of the ingot. Ordinarily, 670° Centigrade is the best temperature for annealing and usually this process is completed in some twenty to thirty minutes. The maximum Brinell hardness of standard silver was found to be about 183, and the tensile strength varied, according to the method of casting, from 22,000 to 28,000 pounds per square inch.

A New Method of Welding

French System of Holding the Welding Rod to the Rear of the Torch

THE usual method employed in autogenous welding consists in holding the torch inclined in the direction of the place to be welded and imparting to it a slight vibratory movement. A new method has been recently described in the French magazine *Revue da la Soudure Autogène* (July-August) called *Soudure en arrière* (Welding to the Rear). In this process the welding rod or filler rod (i.e., the stick which the operator holds in front of the blow pipe and which gradually melts and fills up the space between the edges of the two pieces of

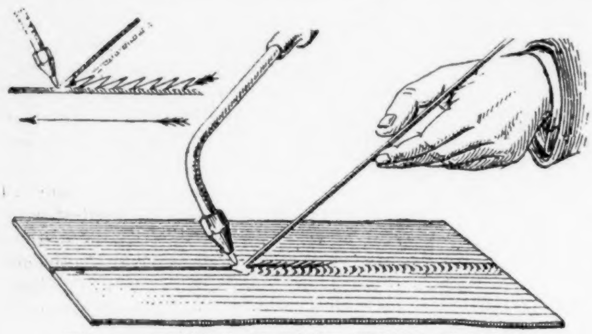


FIG. 1. WELDING OF THICK SHEETS OF METAL

metal that are being joined), follows the torch instead of preceding it. This process, which was devised for welding soft steel by M. Roulleau during the war, and which has been employed in a number of factories, both in Italy and in France, presents considerable advantages: the metal is sounder, the rapidity of advance is greater, and, finally, there is a saving of at least 25 per cent in labor, in gas, and in filler metal.

The fusion of the filler metal is affected no longer directly by the point of the flame but by the heat proceeding from the entire flame, the torch being inclined towards the rear, i.e., towards the welding rod.

The stick of filler metal is pretty smartly inclined with respect to the line of the welding in the forward direction, i.e., in the direction contrary to that of the inclination of the flame. The angle which appears to be the most favorable between the line of welding and the filler rod is 45 deg. for thicknesses starting at 6 to 7 mm. and a little bit less below these down to 30 deg. for weldings upon sheets of metal 3 mm. in thickness.

This inclination, furthermore, is a function of the movement which is imparted to the end of the filler rod in the line of the welding. In thicknesses of about 6 mm. this movement consists in causing the extremity of the filler rod to

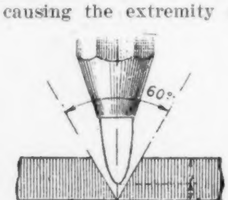


FIG. 3. POSITION OF THE TORCH, TIP OF FLAME IN ANGLE FORMED BY THE CHAMFERS

melt, by moving alternately from one side to the other of the line of welding (Fig. 1). In thicknesses below 6 mm. the movement becomes at first ellipsoidal in character and with sheets of metal having a thickness of from 3 to 4 mm. (and still more so for these having a thickness of 2 mm.) it finally exhibits a back and forth longitudinal movement unaccompanied by a transverse movement (Fig. 2). In both cases the extremity of the filler rod remains constantly immersed in the fused metal.

In order that the welding line may present a homogeneous aspect it is advisable to operate at the same rate of speed from start to finish. Otherwise if one moves the torch too rapidly at one end the free fusion and the regular advance will not be obtained until after the lapse of a certain length of time from the beginning of the welding. It is well, however, previously to heat the sheets of metal with the blow pipe along the line of the weld for a breadth of a few centimeters. The blow pipe and the filler stick are held, as indicated, the tip of the flame penetrating thoroughly into the angle of the opposite chamfers or beveled edges of the sheets of metal, and the first melting is obtained by imparting a slight gyratory movement; then the filler rod is immediately introduced into the molten metal, while at the same time the blow pipe begins to advance at a regular rate of speed. The filler rod, on the other hand, which immediately follows the flame, is given a reciprocating movement, either perpendicular to the edges of the line of welding, or else more or less elliptical or longitudinal, according to the thickness of the metal, but always retaining the same angle of inclination.

By following this method the welding is accomplished in a normal and very continuous fashion. The operator must be careful to employ an amount of filler sufficient to entirely close the line of welding with neither an excess nor a deficiency. Upon arriving at the end of the line of welding the

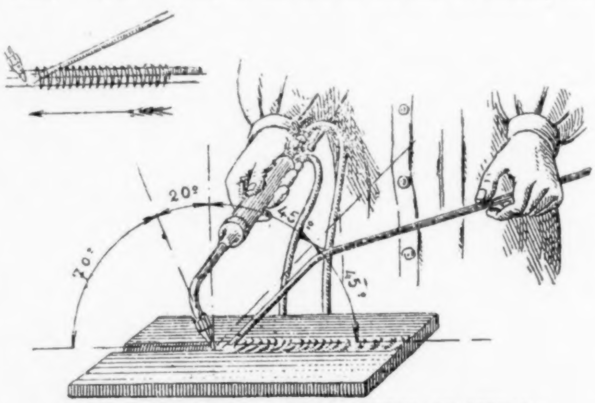


FIG. 2. WELDING OF THIN SHEETS OF METAL

position of the blow pipe is changed as required, in order to secure a neat finish, the blow pipe and the welding stick being skilfully manipulated as in the ordinary process.

Since the molten metal is directed towards the rear, it is always the faces of the chamfers which are attacked; the welding is of the character known as *bien traversé* (well filled), and smears are almost impossible. However, the operator should never proceed with too much speed, but must go slow enough to give the faces of the chamfers time fully to melt, while, at the same time, avoiding the creation, by going too slow, of "candles" of melted metal on the opposite side of the welding by reason of too great an application of heat at the point of the V (Fig. 3).

ELECTROPERCUSSIVE WELDING.

E. VIALL describes a method of jointing wires by connecting the two pieces to the terminals of a charged condenser, and bringing them suddenly together with some force. Sufficient electrical energy is liberated by the discharge to melt the wires, while the force of the blow welds them together.

A machine suitable for jointing aluminum and other wires up to No. 13 gage is described. One wire is held in a chuck at the base of the apparatus, while the other is clamped into a holder free to slide in vertical guides. The holders are connected to the terminals of an electrolytic condenser by a circuit containing an adjustable inductance, and are kept short-circuited till required. The condenser is coupled up to a source of supply through resistances. The wires have their ends prepared by a special cutter, the switch is opened and the upper holder is allowed to fall, when, if all adjustments are correct, a perfect weld is immediately made. Oscillographic tests with No. 18 B. & S. aluminum wire show that the power expended at the weld reaches 23 kw. for an instant, but the entire weld is made in 0.0012 sec., so the total energy is about 0.00000123 kw-hr. per weld. The process is well adapted to welding copper connections to aluminum.—*American Machinist*, March 20, 1920. Abstracted by *The Technical Review*.

THE GREAT HYDROELECTRIC PLANT AT KEOKUK.

THE Mississippi River Power Company's power plant at Keokuk, Iowa, is by far the greatest low-head hydroelectric development ever undertaken. The entire structure is built of monolithic concrete and includes a dam, power house, navigation lock and dry dock. It is located at the foot of the Des Moines Rapids. It is two miles long and is provided with a normal working head for hydraulic machinery of 32 feet. The discharge of the river, at the site of the power station, where it is approximately a mile wide, is 200,000 cu. ft. per sec. at low water and 372,500 cu. ft. per sec. at the flood stage, which discharge made possible the project.

A 4,560-ft. spillway dam of the gravity section type which is surmounted by a bridge, extends from Hamilton, Ill., on the east side of the river, to the power house which is near the west side of the river. It consists of 119 arched spans each having 30-ft. openings and 6-ft. piers. Each of these 30-ft. spillways may be closed by a gate or wier, in other words, there are 3,570 ft. of spillway.

In order that drift and ice may be excluded from the forebay, a 2,340-ft. fender pier was constructed. There is a 300-ft. opening between the shore abutment and the end of the pier to allow the passage of river traffic. When navigation is closed, or when there is a large amount of floating matter in the river, this opening is closed by means of a floating boom.

The completed power house will be 1,700 feet by 123 feet, and will provide room for 30 units each comprising a 10,000-hp. single-runner vertical Francis turbine connected to a vertical 9,000-kva., 11,000-volt, 25-cycle, three-phase generator operated at 577 r.p.m. The present structure is only half of that called for by the plans, and provides for only 15 main generating units. From the forebay the water passes through the gate openings in the gatehouse section of the building., thence entering four branch intake tubes for each 10,000-hp. turbine. These four entry openings, 22 ft. by 7.5 ft. deliver the water to the scroll chamber at the sides and rear of the turbine setting. By the design of the scroll chamber, 39 ft. in diameter and molded in concrete to follow the mathematical curvature required, the water is impinged upon the turbine blades from all sides with equal force and velocity. The draft tubes, 18 ft. in diameter at the rotor, enlarge rapidly as they assume a horizontal direction to empty into the tail race. Because of this design the water, as it enters, moves at a speed of 14 ft. per second and is discharged into the tail pool at about 4 ft. per sec.

A short dam extending downstream from the power house, a navigation lock and a dry lock at the west shore, form the forebay of the power house. The lock is a single 40-ft. lift, the chamber of which is 400 ft. by 110 ft., and may be filled in 10 minutes and emptied in 12 minutes. One of the features of this lock is an upstream gate, which may be described as a single leaf with a void chamber. This gate is operated as follows: To open it the chamber is filled with compressed air, and because of the buoyant effect it floats into place; to close it, the compressed air is allowed to escape, and it sinks into the chamber provided for it because of its weight.

At the present time this station provides 110,000 h.p. to St. Louis, East St. Louis, Alton, Hannibal, Quincy, Burlington, Ft. Madison and adjacent territory and, thus, serves a population of about 1,120,000.—From *Mechanical Engineering*, April, 1920, pp. 228-29.

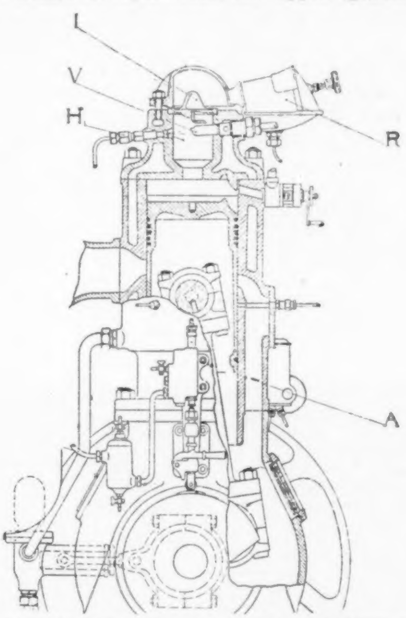
BERGSUND ORIGINAL SURFACE-IGNITION TYPE ENGINE.

THE Bergsund engine is now being built in Sweden but it is likely to be introduced soon on the market.

Its design does not differ essentially from that of similar engines now known. It is shown in section in the accompanying drawing.

The cycle is as follows:

The projecting piece V has a double duty as the fuel is sprayed on it at an acute angle in an almost solid stream, and is split by it into fine particles. And, in order to avoid chance of misfire at light loads, the lipped ignition disk V_1,



BERGSUND ORIGINAL SURFACE IGNITION TYPE ENGINE TYPE ENGINE

termed the light-load ignition surface, is fitted just above it, and this enables the engine to run for long periods without load, or without the use of the blow-torch.

Fuel oil is injected by the pump into the hot-bulb "T" via surface V, which is heated when starting by transmission of heat from the double-lipped disk I, which is made red-hot by the blow lamp R. After the engine has been running a short time, the blow lamp is extinguished and the projection R and the ignition plate are kept hot by the temperature of combustion. It will be noticed that both the hot bulb and the injection nozzle H immediately before the piston reaches top center, and is sprayed on to the surface of the projecting cylinder head are water-cooled.

Fuel is fed to the injector by the pump A which is actuated by a cam on the governor. The governor regulates the position of the cam in such a manner that the stroke of the pump is suited to the load of the engine, hence the quantity of the fuel being varied. Before entering the cylinder, the fuel-oil is passed through to separate filters, one of which may be taken out and cleansed while the engine is working. All troubles from the choking-up of the fuel oil valves and the nozzle are obviated by this arrangement.—*Motorship*, Vol. 5, No. 6, April, 1920, pp. 324-326.

Drilling an Oil Well in Pennsylvania

Methods of Boring and Details of Machinery Used

By Herbert T. Wade

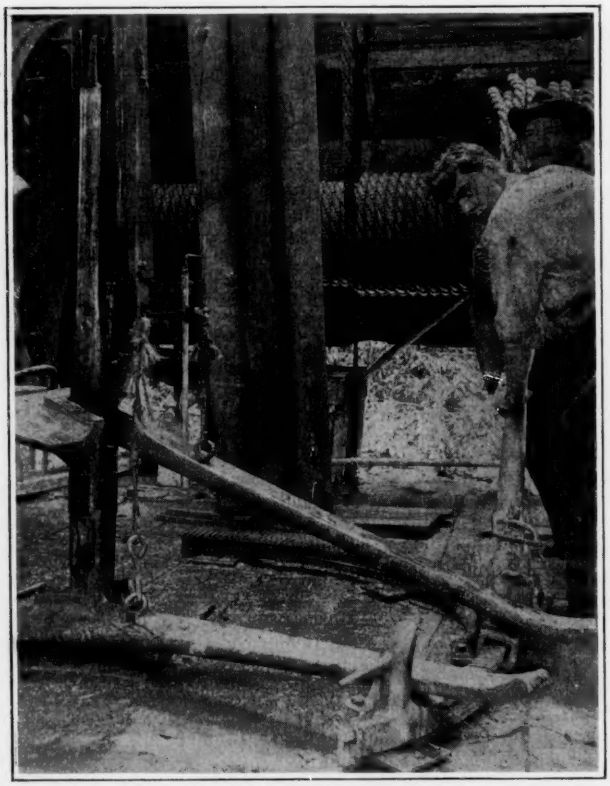
THE sinking of bore holes into the surface of the earth in the quest for petroleum or natural gas involves interesting equipment as well as operation, which has been developed in the course of comparatively few years. Despite the general rough appearance of a drilling installation in the oil fields, in most instances drilling methods and machines are quite efficient and extraordinary depths have been attained in a number of instances.

To appreciate the general nature of the operation it must be borne in mind that there are two fundamental elements in sinking a deep bore hole, namely, drilling and hoisting, and the installation must be designed with these ends always in view. Drilling may be done either by percussion, hydraulic, or abrasive methods, depending upon the nature of the material to be penetrated, and in different countries and in different oil fields there are variations in the processes and equipment. The American standard cable or percussive system developed in the Appalachian field consists of cable tool drilling or raising a steel drill by a cable and permitting it to fall of its own weight and thus make its way through the material. In California and other fields the rotary system is employed where a column of pipe whose lower end is fitted with a cutting tool is turned in the bore hole.

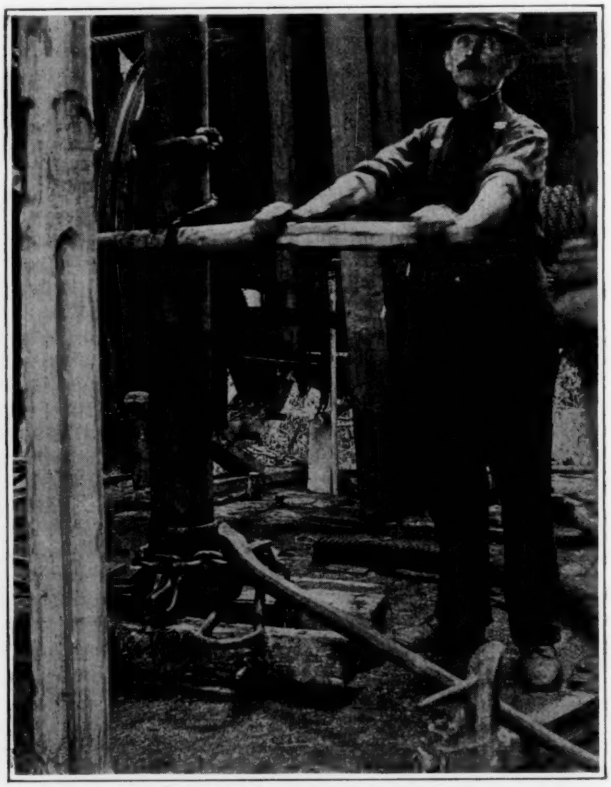
In the main there are two grand groups of drilling installations, first the portable or drilling machine readily moved and generally speaking limited by about 2,000 feet depth of operation, and secondly the drilling rig designed to be installed permanently at the selected location, and in some cases susceptible of being dismantled, removed and reassembled and erected elsewhere in equally permanent form.

The leading feature of the drilling rig is of course the tower so familiar in the landscape of any oil field. A drilling outfit such as may be found in Pennsylvania, West Virginia, Oklahoma, or elsewhere in the United States consists not only of the drilling structure, that is the derrick and its appurtenances, but also the tools, engines, boiler, rope, and other accessories. These outfits in many cases are owned and operated by contractors, and in sinking a gas or oil well by contract it is usual for the drilling rig and casing, that is, the protecting pipe lining the bore hole, to be furnished by the owner, while the tools, engines, boilers, etc., are supplied by the contractor who is paid on the basis of the distance drilled.

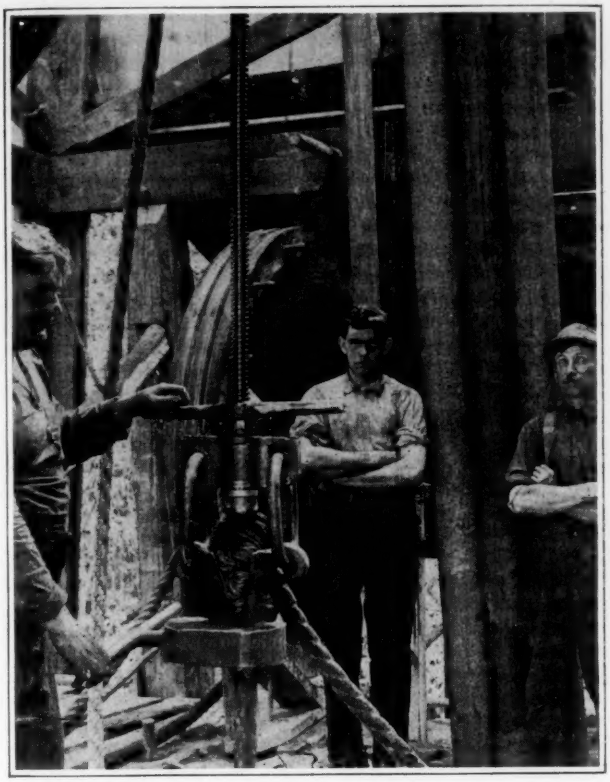
The most usual equipment seen is the old-fashioned timber tower rig, parts of which are shown in the accompanying illustrations. Naturally the drilling rig is an evolution which began with a spring pole supported on a tripod or forked post, and carrying suspended at one end the drill. This was succeeded by a braced mast single or double. Then came the modern four-legged braced derrick of timber intended to remain permanent. In all of these the object was to secure an arrangement which would raise and lower a drill tool or bit, and later serve to support and lower a lining of iron or steel pipe or casing in the bore hole. The next development of the timber derrick was to design it so that it could be put together readily with bolts and then taken down and removed elsewhere in case of lack of success or for other reasons. Follow-



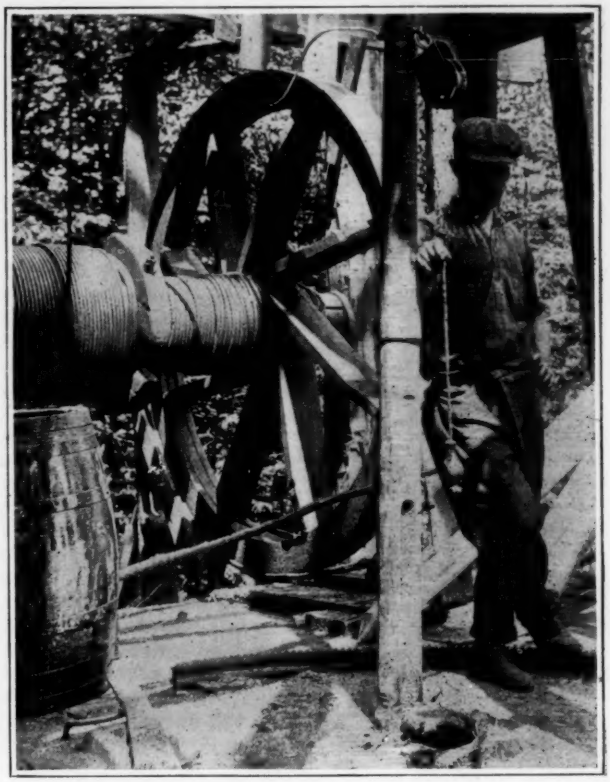
DRILLING BIT BEING SCREWED WITH A 200-LB. WRENCH. NOTE "BULL WHEEL" IN THE BACKGROUND



THE CASING BEING SCREWED TOGETHER WITH "CHAIN TONGUES" AND "NEVER SLIP" PIPE WRENCHES



VIEW OF THE TEMPER SCREW. THIS ADJUSTS THE DEPTH OF THE DRILL



STEEL TAPE BEING LET DOWN INTO THE WELL TO MEASURE THE PROGRESS DEPTH

ing all structural development there came derricks constructed from the abundant supply of pipe to be found around oil wells, and then a special steel structure designed to furnish with greater strength and permanence the facilities required. A long panel construction at first was turned out by construction engineers based in many cases rather upon theoretical and preconceived ideas than upon the demands and standards of field practice, but this later was modified in a steel derrick with short panels in which the best features of the long established wooden tower were retained and the demands of the men in the field met. Today the most approved practice demands the use in new installations of structural steel not only for the towers, but for the support of the machinery, framing of the buildings, which are covered with sheet metal, and wherever else required.

The comparative recency of all this may be appreciated from the fact that while a well for brine had been sunk as early as 1806 at Charlestown, W. Va., the first well drilled for oil was the Drake well sunk by hand at Titusville, Pa., in 1859. The beam either in the form of a spring pole or balanced beam already referred to was employed by the Chinese and was a feature of early installations in the United States.

As suggested this developed into the four-legged braced wooden tower which by 1866 had come into general use, and as modified in many respects and of increased size is widely found today in the United States. The wooden rig had and has the advantage of speedy and easy construction and it could be readily strengthened in case it was found too light, while timber was generally accessible in the oil fields. Furthermore, in case the well proved productive the tower and power plant could be left in position for the pumping machinery which would take the place of the drilling outfit.

It will be apparent that the arrangements mentioned are necessary to deal with the great depths involved in lowering drills, etc., and in fact with a well running over 3,000 feet in depth careful provision and adequate and permanent equipment must be installed. The derrick which is from 60 to 110 feet in height is required to facilitate the hoisting and lowering of the string of drilling tools, the casing, sand pump, and other adjuncts. At the top is the crown pulley over which passes the cable, usually a 2-inch manilla rope which carries the string of tools that terminate in the drill or cutting bit. The cable is connected to a walking beam by a "temper screw," shown in our illustration, which also permits the drill to be lowered between strokes and its cutting regulated. The walking beam is carried on a "Samson post" and is connected at the opposite end from the cable by a pitman with a so-called band wheel driven by a steam engine or directly attached to the wrist pin of the main driving shaft, the object being to give through the walking beam an up and down motion to the cable carrying the drilling tools. The boiler is usually located some distance from the engine for reasons of safety.

The drilling tools in size and weight adapted to the nature of the material being penetrated and the depth of the operation, are duly lifted and fall under their own weight, pulverizing the rock. These tools are strung along in a formidable array and their total length amounting to some sixty feet or so, in part is responsible for the height of the derrick. The arrangement of tools from the bottom up is as follows: First comes the drill proper or cutting bit, varying from the broad cutting edge found in the "spudding" bit used in earth or sand at the beginning of the bore hole to the drilling bits for rock, their cutting edges varying of course with the diameter of the hole. The bits also vary in weight and are threaded at the top so as to be screwed to the next element, namely, the augur stem a long steel bar anywhere from 12 to 45 feet or so in length. Next come the jars, a loose link arrangement capable of about 16 inches movement, whose function is to free the drill by affording an upward jarring blow on the up stroke. Then comes the sinker bar and finally the rope socket at its upper end. It will be seen that screwing the elements of the drilling section together can be done only by the use of large

wrenches which hold and turn the bits and other bars. The illustration shows a couple of these 200-pound wrenches being used in screwing a drilling bit to the augur stem.

While the temper screw provides for the depth adjustment of the drill without removing the tools, yet from time to time these must be raised clear of the bore and new drills substituted. In that case the cable which passes over the crown pulley to the bull wheel is regularly wound up and the tools hoisted out. The loose material such as the pulverized rock and sand is removed by a sand pump and a bailer with a dart valve at the bottom is lowered on a separate and small line passing over its own pulley and wound up on its own windlass. It may be said here that the bailer in addition to clearing the bore also gives the indications of the material that is being penetrated and samples are taken, washed, laid out in order, for the study of the driller, engineer or geologist, and traces of oil or oil bearing sands are carefully looked for and noted.

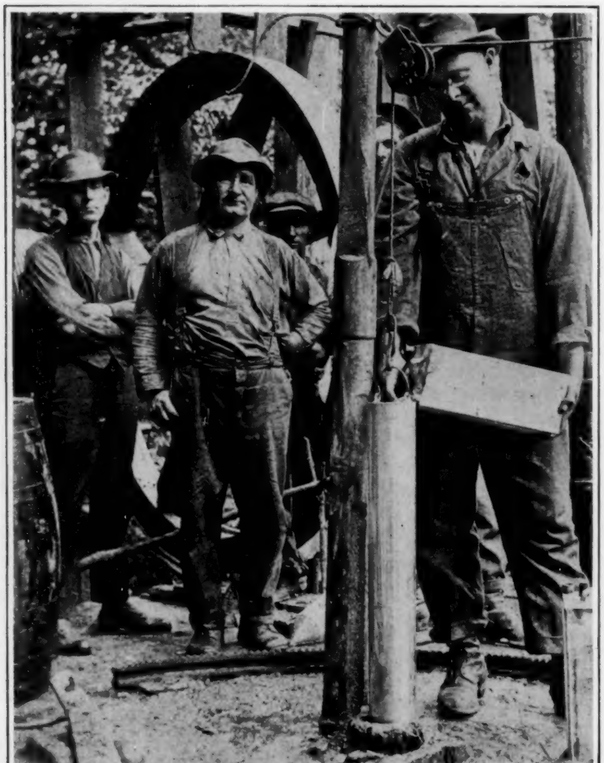
It must not be inferred that the regular drilling operations begins at once in sinking the bore hole. There must be secured at first sufficient depth to permit the string of tools to be lowered and often the first drilling is through earth, clay, sand or gravel, where it may be possible to sink a steel pipe directly or by hydraulic or other means until rock is reached or the spudding tool referred to may be used. This tool as stated has a longer cutting edge, usually about 12 inches and is not operated from the walking beam but is attached to the cable and lifted and dropped by means of a jerk line, one end of which is attached to a crank or wrist pin on the band wheel or main shaft and the other to the cable near the bull wheel. In this way a short, quick stroke is communicated to the cable and drill which cuts its way through the surface soil or sand quite rapidly.

At first some form of large casing may be inserted in the bore or a drive pipe is lowered until rock is reached. When the regular rock drilling begins the bore must be protected from caving or the ingress of water by means of a casing of iron or steel pipe which is carefully jointed sometimes with packing rings and lowered down in the well; this operation of the pipe wrench arrangement being shown in one of the illustrations. Usually in the case of a deep well the lining or casing diminishes in diameter as the depth increases much after the fashion of a telescope tube.

The work of the contractor sinking the well may run smoothly and therefore profitably to him, or he may encounter difficulties that will diminish his profit or even involve a loss. The cable may break, dropping the tools. The tools themselves may come unscrewed or the stem may break. The casing may drop into the hole, or other mishaps occur, many of which involve "fishing," often an arduous job for which many tools are provided. Usually this work is successful, but it may require that the bore must be abandoned and a new well sunk.

Ordinarily enough is known of the nature of the location so as to plan the drilling, and the size of the hole started depends upon the number of times it is to be cased. Of course successively smaller drills are used the greater the depth. The driller at the tempering screw is able to tell the nature of the material, for a rapid letting out indicates a soft rock such as coals or shales are being encountered, while the reverse is true for the hard strata. The drill on removal from working in soft material will have a muddy appearance, but if it has been cutting through hard shale the bit and stem will appear bright and polished, while in solid, hard formations the cutting edge of the bit will be roughened in such a way that to the expert the "feel" will indicate conditions.

If a well of promise is obtained, and also when it is desired to increase the flow of oil or attempt to restore a decadent well, the next consideration is shooting in order to shatter the rock or pay sand at the bottom and thus permit a freer flow to the well. This shooting or torpedoing is done by lowering a shell filled with nitro-glycerine to an amount



SHELL BEING FILLED WITH NITROGLYCERINE PREPARATORY TO SHOOTING THE WELL. NOTE DRILL ALONGSIDE

A "JACK SQUIB" LOADED WITH DYNAMITE CAP AND FUSE READY TO BE DROPPED INTO A WELL FOR A SHOT

sufficient to occupy the entire distance opposite the pay streak or sand and then exploding it by some form of detonator. The shell is from 3 to 5 inches in diameter and from 5 to 20 feet in length sometimes in sections and is detonated either by means of a "go-devil," a leaden weight sent down on a cord to strike a percussion cap, or in more modern practice, by a squib loaded with dynamite and having a time fuze as well as percussion mechanism, which is dropped to the bottom and there detonates the nitro-glycerine.

The oil well is finished by lowering a pipe within the casing through which the oil flows under natural pressure or is pumped. It is then led to field storage tanks and to pipe lines to the refineries or to storage tanks.

While in these unsettled times it is of little value to refer to costs, yet it may be stated that under previous normal conditions the cost of drilling ran from $1 to $15 a foot or more, the deeper the well the greater the cost and the rate of progress was said to run from 60 feet a day to 10 feet for the deeper bores. It has been estimated that the cost of drilling a 3,000-foot well under present conditions would run from $50,000 to $80,000 or more.

The illustrations shown and the methods described apply only to the Appalachian field, but the modifications in other American regions, except perhaps in California, where there is more rotary drilling, are minor. With the increased attention given to oil development there have been improvements in machinery to which competent mechanical engineers and manufacturers have directed their attention so that much of the rough and ready equipment of earlier days has been supplanted by better machinery and devices. There are also diversities from American practice in Canada and of course to a much greater extent in foreign countries.

Peat as a Possible Source of Industrial Power*

Economic Factors Involved in Its Competition with Coal

By Herbert Philipp

THE use of peat as a source of heat goes back beyond the historical period into the ancient history of the early tribes in northern Germany. Pliny, the Roman naturalist, gives us possibly the first indication of the use of peat. He reports that the Teutons on the border of the North Sea dried and burned mud, what we now would call peat. In Ireland, Great Britain, Russia, Scandinavia, Germany, Holland and parts of France peat has been used as a fuel since time immemorial. The peat was cut from the bog very much in the same manner as it is still being done in many parts of Europe, where it is cut in brick shapes, allowed to dry in the wind and sun and stacked up, just as the American farmer piles his cord wood.

It is only in the last seventy years that any progress has developed in this industry, and although very little has been done in this country to obtain efficient results in using peat as a source of power, much can be expected in the near future of making this resource valuable and an economic factor in our industrial life.

EXTENT AND FORMATION OF PEAT DEPOSITS.

Peat is disintegrated vegetable matter accumulated in areas of poor drainage where the chemical decomposition has been partly retarded according to a variety of conditions. Some of the conditions have resulted in complete decay, so that the original substances have disappeared, while others have simply resulted in the loss of more easily changed compounds and gaseous elements, the material retaining its original form and mechanical structure. The deposits of peat are not uniformly distributed over our country, but occur in practically every state east of the Dakotas and north of the Carolinas to the Canadian border. This is supplemented by deposits all along the Atlantic coast, the state of Florida and across Texas to the Mexican border. In the Pacific coast states are some areas of peat deposits, especially in California and in the valleys of some of the lakes and rivers of Oregon and Washington. It is estimated that there are approximately 12,000 square miles of peat deposits in the United States of an average depth of 9 feet which would represent a total of about 14,000,000,000 tons of fuel, provided the whole were converted into peat fuel, which is no small resource and represents a possible means of furnishing heat and power for a considerable number of years.

It is only in recent years that peat has become of enough interest in this country to endeavor to classify the various kinds which are made. This work is being undertaken by Dr. Alfred P. Dachnowski of the U. S. Bureau of Plant Industry, and his initial attempt represents an admirable contribution to our peat literature. The terms muck, humus, moor, marsh (fen), bog, heath and swamp are terms used without any definite relation to the stage of development of the peat in the deposit. These terms usually relate to the marked physiognomy of vegetation appearing on the deposit. A peat deposit can be defined as a compact accumulation of plant remains of at least 8 to 10 inches (20 to 25 cm.) in thickness. No deposit containing more than 40 per cent of mineral matter must be included in this definition. Peat deposits usually occur upon gentle slopes, flat areas, in shallow depressions on the earth's surface which are poorly drained so that the surface is always wet or covered by water.

Owing to the various conditions under which peat deposits have been formed and to the various types of vegetable matter composing them and also to the various locations and climatic changes to which they have been exposed, each deposit is practically a study in itself. There are possibly no two deposits that are exactly alike, although a large number may be very similar in composition. This explains one of the reasons why difficulties have been met with in trying to work one deposit by means adapted on another deposit.

GROWTH OF PEAT INDUSTRY.

A peat industry exists in this country, and has grown steadily the last twelve years till it now represents a real industry. However, only a small quantity of peat up to the present time has been manufactured for fuel purposes, the largest amounts being used in agriculture and in the fertilizer industry. The statistics in the table show the amount of peat produced and also the quantity used for fuel purposes.

Crude Air-Dried Peat and Peat Fuel Produced in the United States, 1908-1918.

Year	Total Peat Produced Short Tons	Total Peat Fuel Used Short Tons
1908	24,800	900
1909	29,167	1,145
1910	37,024	......
1911	55,143	300
1912	47,093	1,300
1913	33,260	......
1914	47,093	1,925
1915	42,284	......
1916	52,506	......
1917	97,363	......
1918	151,521	20,567

*Paper read before the New York Section of the American Electrochemical Society, Feb. 27, 1920.

It will be noted that during the last few years the production of peat has practically trebled due to the extensive application of this material in fertilizers. It will be well to mention here that peat in this country is generally comparatively rich in nitrogen, and that is the reason why the use of peat in agriculture is proportionately greater in the United States. The peat fuel production was negligible until 1918, when the high price of coal gave quite an impetus to this industry, and the future offers very promising developments for a successful peat fuel industry in this country.

In Europe practically all the peat which is excavated is used for fuel purposes. Since coal has become high in price and as far as we can determine will remain so, peat becomes an economic factor in our future industrial progress.

MANY FAILURES TO PRODUCE PEAT ECONOMICALLY.

A large number of attempts have been made in the past to produce peat fuel economically, but the majority have proved uncommercial and we cannot speak of any successful peat fuel undertakings before 1918. The large number of failures were due to many factors which were, chiefly, lack of capital, poor engineering, difficulties of distribution, prejudice, stock jobbing, and competition of low priced coal. From this it will be seen that too many efforts have been made with small capital and poor engineering ability to allow the industry to get on its feet, and that has for years given the industry a bad reputation and prevented any attempts being made on a big scale and has generally created ridicule in suggesting a development of a peat fuel industry. With the present high price of fuel and the inability to obtain a steady supply, a peat fuel industry is now looked upon as a remunerative possibility.

There is more than one way of utilizing peat for the production of industrial power, yet whatever method is used the peat must first be excavated from the deposit, and the economic excavation of peat has been the biggest bugbear in the peat industry.

OPERATION FEASIBLE ONLY IN DRY SEASON.

The average peat deposit contains from 80 to 90 per cent water, and that must be economically driven off to make the peat available as fuel. It will therefore be easily realized that for every ton of raw peat excavated there is only 100 to 400 lb. of theoretically dry peat available. Peat deposits vary, and according to the grade of decomposition they will dry in the air at various rates. The more highly a peat is decomposed the more quickly will the moisture evaporate and the more fibrous the material is the more slowly will it evaporate. This phenomenon is due to the fact that the moisture present is not all there as absorbed moisture, but the water present is in the cells of the vegetable mass. It is therefore necessary in most cases to pass the peat through a pugging or macerating mill.

DEPENDENCE ON LOCAL CLIMATIC CONDITIONS.

In order to obtain a cheap fuel it can be inferred that peat cannot afford to be handled very much, and therefore the larger part of the drying has to take place on or near the deposit. It is manifestly unfeasible to use any artificial heat for producing peat fuel. However, there are conditions where waste heat can be used to advantage to reduce the moisture content of peat, as will be shown later. There is no cheaper method of drying than by nature herself, and the sun and wind have to accomplish the larger part of the drying in any development of a peat fuel plant. This shows how dependent the industry is on local climatic conditions—not only on the total hours of sunshine, but also on the winds and humidity of the atmosphere. Further, the temperatures of the season play a big factor in the excavation and drying of peat; it is impossible to excavate peat when the ground is frozen. In other words, enough material has to be excavated in the good season of the year to supply a plant for the whole twelve months, and this is the point that so many plants have failed to realize, so that they have been forced to shut down for lack of material. The length of time that excavation work can take place varies with the location of each deposit and due regard must be paid to the climate of the locality.

MECHANICAL EXCAVATING AND HANDLING APPARATUS.

In most countries the peat is commonly used as fuel and the hand digging of peat is still used. The mechanical handling of peat, which originated in Germany, is only being taken up by deposits where large amounts of peat have to be excavated. Where peat is used as an industrial fuel, only mechanical excavating and handling apparatus can be considered. There are two possibilities of opening up a peat fuel deposit or peat bog; namely, the operation of excavating a dry peat bog and the excavation of peat from an undrained swamp.

In the first case that part of the deposit which is to be used is drained, generally by preparing small ditches which lead into a main ditch. The deposit is then cleared and leveled so that the surface can be used as a drying ground. These ditches should not be too deep and should not go beyond the depth of the deposit to prevent in the latter case contamination with mineral substances. It is often necessary during the winter season to allow the water to accumulate in the deposit and in case the deposit takes fire it can be quenched by allowing the water to rise in the ditches.

The machines used for excavating the peat are generally of the simplest form of construction and are similar to those used ordinarily in ditching and digging. The modern tendency in using power ditching machines corresponds to the types of side chain and bucket excavators, which are very effective in peat which is well decomposed, but cause trouble in poorly decomposed deposits on account of tree stumps which have not yet disintegrated. These machines generally work from the side of the ditch, which has the advantage of mixing the peat from the different depths and thereby securing a homogeneous product. On account of the high cost of labor in this country the peat excavated, even in small plants, is found to be done more economically by machines than by hand digging. The steam shovel has also been used in this country and gives satisfactory results. On account of producing homogeneous material and the ability to spread the material more easily on the drying ground, the chain and bucket excavator seems to be most favored.

DIFFICULTIES TO BE OVERCOME.

In devising machines of this nature not only has the ability of excavating efficiently to be taken in consideration but also the expense and labor incurred in handling the material after it leaves the excavating machine. As peat deposits will not hold a very great weight per square foot, thought has to be given properly to mount the machine so that the weight is distributed as uniformly as possible. The machines are generally mounted on cars having wheels with very wide treads, which have on some deposits, even then, to be supplemented by timbers. The more modern machines are provided with caterpillar tractors, which have proved very satisfactory in this kind of work. Where possible these machines are operated by electricity, otherwise the power plant has to be installed on the machine. However, this should be obviated as far as possible on account of the possibilities of setting fire to the deposit during the dry season. Peat fires can become very disastrous and are often very hard to put out.

NO STANDARD PEAT DIGGING MACHINES.

There are no standard peat digging machines in this country, and generally in each case they have to be designed to meet the local conditions. These machines have to be of an efficient form and provided with a hopper for receiving the peat which falls into a cutting or macerating trough, thus pulping the peat and cutting up its strands. These macerating machines are provided with screw conveyers and on the

same shaft can have knives for cutting up the fibers, while other machines have sections provided with both fixed and movable knives which work together like the blades of scissors.

After the peat has passed through the above-mentioned machinery, it is then spread on the drying grounds, which is generally the surface of the deposit, and here exposed to the sun and wind. Every once in a while a new surface of this layer is exposed and eventually the material is scraped together and hauled to the plant. By this method peat originally containing 80 to 95 per cent water can be dried down to 25 to 35 per cent water right on the field, and this moisture content is low enough where peat is used in gas producers, but for cases where it is used for making steam direct it should be dried down to about 15 per cent water, although 20 per cent is frequently used; in a large power plant this can generally be accomplished at the plant, where enough waste heat exists to reduce the moisture content economically.

In excavating an undrained deposit the machinery has to be mounted on a barge or float and either a dipper-dredge or pumping system is used. Both of these systems are satisfactory; their use depends entirely on the local conditions, quantity of peat to be handled and its stage of decomposition. In each case, however, the peat has to be handled on drying grounds after it leaves these excavating machines. Highly decomposed peat can be very efficiently handled by pumping if very little fibrous matter is present in the deposit.

COSTS AND METHODS OF BURNING PEAT.

The cost of excavating and air drying peat governs the success or failure of a peat fuel plant. All the cost involved in handling the peat from the deposit to its storage pile should not exceed $1.30 per ton of theoretically dry peat. The cost depends very much on the size of the excavation plant and on the climatic conditions. My experience in excavating peat covers a cost ranging between 25c and $1.30 per ton of theoretically air-dried peat on the field. It is seldom that the excavation price exceeds $1 per ton of peat, the average being in the neighborhood of 75c. per ton of theoretically dried peat.

In producing power from peat we have available the same methods as are now used for coal, either firing peat direct under a boiler for raising steam or gasifying it in gas producers and using the gas in gas engines or under boilers and in furnaces. Where industrial power is produced from peat, it is necessary to locate the power plant at the edge of the deposit or in very close proximity thereto. The reason for this is that the handling of large quantities of peat fuel involves several problems of a serious nature; on account of its bulkiness and low heating value, compared to coal, it necessitates handling larger volumes and burning an appreciably larger quantity than is the case when coal of a good quality is used for raising steam. Furthermore, very large stocks of peat fuel have to be held, and the sensible heat contained in the flue gases, together with exhaust steam, is used to advantage in reducing the moisture content of the air-dried peat. Peat fuel generally burns freely to a fine, easily handled ash. Thus it is practically totally consumed and the handling of the ash is reduced to a minimum.

ANALYSIS OF GOOD PEAT FUEL.

An approximate average analysis of a good peat fuel is as follows:

	Per Cent
Volatile matter	60
Fixed carbon	30
Ash	8
B.t.u., 8,500	

When peat fuel is burned direct on a grate it is necessary that not too much fine material is mixed in the lumps and it is therefore frequently advisable to briquet the peat before using it for such purpose. Many peats have enough binding material present in them and others will not hold together at all unless mixed with pitch or similar material. In making machined peat it is advisable to form the bricks while the peat is still plastic and then let them dry. Some peat briquets form easily without the addition of any foreign binder, especially when heated up to about 100 deg. C., when the natural paraffine present will hold the peat in its form and produce briquets which are comparatively easy to handle.

REQUISITES OF BOILER FOR USING PEAT FUEL.

The points to be considered in constructing a boiler for using peat fuel are a large grate area with very small air spaces, large combustion chamber, and long travel for the flue gases; 15 lb. of peat per sq. ft. of grate per hr. has been found good in practice. Peat has a disadvantage in allowing unburned hydrocarbons and hydrogen to escape in the ordinary combustion chamber built for burning coal. It is therefore necessary to have a specially constructed combustion chamber to insure complete combustion when using this fuel. Peat has another disadvantage, because when firing with peat the fire door has to be open quite a considerable part of the time, because men cannot handle as much peat on a shovel as coal owing to its low specific gravity. However, if the peat is used as a pulverized fuel it will be found not only economical to prepare but can compete with coal more advantageously.

When peat is dried, even air dried, it does not absorb moisture from the atmosphere very readily, and even with 20 to 25 per cent moisture content it has the physical characteristics of a dried material. Provided it has been properly macerated it is very easy to pulverize and will not pack, running and behaving similarly to dried sand. With these conditions, together with its low specific gravity and high combustibility, it makes an ideal powdered fuel. Peat has been used in this way in Sweden and has shown that it is possible to obtain better calorific value than by burning the peat on a grate, and every indication points to the fact that peat fuel can be used practically and commercially for raising steam when used as a powder, so the future developments of the use of peat as an industrial steam raiser will tend to be in this direction.

COST AT WHICH PEAT CAN COMPETE WITH COAL.

The maximum cost per ton which peat fuel can stand and still compete with coal is governed by the cost of steam coal at the place where the power plant is located. There is, however, a fixed minimum cost, determined by the cost of its manufacture, below which peat fuel cannot compete with coal. Peat used directly under a boiler for raising steam can generally compete with good steam coal costing $4.50 or less per ton or $4 or less per ton when the peat is used in a pulverized condition. Above this price where peat deposits which are suitable for fuel are available, they become a serious competitor of coal. The more economical method to convert peat fuel into power is to burn the same in a producer to form combustible gases and then use gas engines or burn the gas under boilers to obtain the desired results.

Inasmuch as peat used for generating steam contains generally from 16 to 21 per cent moisture, less water is evaporated than would be the case if peat were theoretically dried. Peat of this nature directly on the grate will evaporate on an average 4 lb. of water per lb. of peat, while pulverized peat evaporates about 5.25 lb. of water per lb. of peat powder.

PEAT PRODUCER GAS.

The most economical method for producing power from peat is to convert the peat into combustible gases in a specially constructed gas producer, or if the gas contains any nitrogen to burn the same in a byproduct recovery producer. Since several of the peats examined in this country have a high nitrogen content, it would be possible to recover the largest part of this nitrogen in the form of ammonia.

The commercial use of peat in gas producers seems to have been successful in Germany and Sweden, where they have been used for several years in metallurgical operations, brick and glass making and in lime burning. Tests have been made on this continent both in Canada and at the fuel-testing stations of our Government, where it has been shown that gas of good calorific quality can be produced, similar results being obtained as in producer gas from bituminous coal. About 40 cu. ft. gas is produced from a pound of peat having a calorific value from 130 to 150 B.t.u. per cu. ft. These producers have the great advantage that peat containing as high as 25 per cent or over of moisture can be used. The most economic method of course for using this is for driving gas engines, but engines of large units have not yet proved very satisfactory in this country. In Europe they are operating and have been for a large number of years apparently with a high degree of satisfaction. It therefore appears that for the present it would be most desirable to use this gas under boilers for raising steam.

AMMONIUM SULPHATE SUCCESSFULLY RECOVERED ABROAD.

When the peat contains nitrogen, the latter is converted in the producer to ammonia, which can be recovered as ammonium sulphate and prove very profitable. There are several plants in existence in Germany, Italy, Holland and France where the Mond producer, modified by Lihme, is working very successfully. In these producers, gas of about the same quality and quantity as described above is obtained and in addition thereto about 80 per cent of the nitrogen is recovered as ammonium sulphate. These producers are very useful to the peat industry inasmuch as peat containing as high as 42 per cent moisture can be used satisfactorily. In Germany peat containing 50 per cent water and 1.05 per cent nitrogen has been operating for eight years or more delivering a gas of 150 B.t.u. and producing 70 lb. of ammonium sulphate per ton of theoretically dried peat. The nitrogen content of the Italian peat is 2.3 per cent and they recover 215 lb. of ammonium sulphate per ton of theoretically dried peat.

Previous to the war the peat was excavated, dried and conveyed to the producers at a cost of 60c. per ton of peat (theoretically dried). In an ammonia recovery producer the ammonium sulphate obtained will generally cover the total cost of the peat and also the maintenance and operating expense of the gas plant, and even then show a profit. When peat has to be converted into combustible gas it is very easy for a power plant to take this gas and use it for raising steam or generating power by direct explosion in a gas engine. The gases from a peat producer are composed on an average of 20 per cent carbon monoxide, 9 per cent carbon dioxide, 1 per cent ethylene, about 4 to 5 per cent methane and 6 per cent hydrogen; while an average gas from an ammonium recovery producer contains 10 per cent carbon monoxide, 20 per cent carbon dioxide, 20 per cent hydrogen and 5 per cent methane. The building of large gas engine units to use low power gases cannot be an impossibility. Since this has been achieved satisfactorily in Europe, our American power engineers must make up their minds to design an efficient engine of this type, else they will have to be imported from Europe. The power engineer can easily realize from the figures given that we have here an economical and cheap source of power, but it must be realized that economic results cannot be obtained unless large installations are designed and that our capitalists must be willing to break a new patch in developing and utilizing a resource so easily obtainable.

CONCLUSION.

There is no difficulty whatsoever in either using a peat for steam raising as a powdered fuel or using a peat in a gas producer. The difficulties, or better the failings, in producing peat as a source of fuel lie in the lack of attention which has been paid to the excavation and drying of the same and the poor engineering ability which has tried to overcome these troubles.

RUNNING MARTIN FURNACES WITH COLD COKE OVEN GAS.

FR. SPRINGORUM reports on recent attempts carried out at the Hoesch Steel Works to heat Martin furnaces with cold coke-oven gas.

The experiments were started in 1913. A 30-ton furnace, heated with producer gas and fitted with ordinary ends, was altered according to März's suggestions and heated with coke-oven gas. These attempts having proved satisfactory, a second 30-ton furnace was laid down in 1913, while in 1914 three 100-ton furnaces were installed in the new Martin steel works to run off coke-oven gas. As regards the modifications made in the furnace for the new system of heating, mention may be made of a new wrought iron water-cooled tuyère 120 mm. diam. which was built in for conducting the gas to the hearth space. The tuyères have proved very satisfactory. Experience in working has shown that the calorific value of the gas is the deciding factor as regards the economy of the method. At the outset this value was 4,300 to 4,500 large calories, the gas consumption working out at 300 $m.^3$ per ton of steel produced. In this connection the larger furnaces were more satisfactory than the small ones.

The duration of a 30-ton heat was 5 to 6 hours, and of a 100-ton heat about 9 hours. Later on, the extraction of benzol and other factors caused the calorific value to deteriorate and it fell to 4,000 cals., the duration of heat rising accordingly. In the case of the 30-ton furnace, melting at a calorific value of 3,800 cals. was uneconomical, whereas the larger furnaces were less sensitive.

Considerable hearth space is required for the perfect combustion of the coke oven gas, as the velocity of admission is high and the fine jet of coke oven gas must first of all be expanded by heat so as to mix thoroughly with the air.

The writer indicates the following advantages attendant on heating: Coke oven gas is anhydrous and poor in sulphur, so that it is possible owing to the high hydrogen content easily to provide a reducing atmosphere over the bath, which is of great advantage in the production of high-quality steel for preventing excessive oxidation and decarburization. The manganese consumption is lower throughout than when working with producer gas. Coke oven gas burns with an almost invisible flame, so that the whole bath can easily be inspected. In addition, a saving was effected in refractory bricks, in wages and steam; and, further, running on producer gas can be entirely excluded.—*Stahl und Eisen*, Jan. 1, 1920; *Zeitschrift des Vereines deutscher Ingenieure*, Jan. 24, 1920. Abstracted by *The Technical Review*.

METHODS OF DRIVING BLOWERS IN STEEL WORKS.

THIS article, of which the present conclusions form the final instalment, discusses the relative merits of different kinds of drive for blowers in view of present day conditions.

In arriving at any estimate of the cost of running, the two factors should be considered, viz.: (*a*) the price of coal will be much higher than pre-war prices for a long time to come; (*b*) all large steel works in Germany have turned over to 3-phase current for power transmission. The author therefore thinks the blower of the future will probably be either (1) driven direct by the gas engine; or (2) by a three-phase motor supplied by current from the gas generating station.

The assumption that with electrically driven blowers a motor of the same power will be necessary as would be required with the direct-driven blower is wrong, as a blower drive is of an intermittent character in which no-load, hot-blowing, charge-blowing and intensified blast alternate. The author cites an actual example of a blower operating in a certain works, and gives figures which show that the power station will, on an average, have to allow for a load of one-half more than the consumption of the blower.—*Zeitschrift des Vereines deutscher Ingenieure*, Jan. 17 and 24, 1920. Abstracted by *The Technical Review*.

Three New Sources of Fuel Alcohol*

Production of Alcohol from Molasses, Wood Waste and Acetylene

GERMANY which, prior to the war manufactured alcohol only from potatoes and grains, when compelled by the Allied blockade to conserve its food supplies, resorted to different methods of alcohol production, some of which were formerly commercially impractical and others entirely unknown in that country. These include the following processes:

a. Process based on the use of molasses.

b. Process utilizing the sulphite liquor of plants for the purification of wood pulp.

c. Process consisting in saccharifying wood and fermenting the sugar thus produced (grain alcohol from wood).

d. Process of generating alcohol by the hydrogenation of acetic aldehyde, which in turn is obtained by fixing the element of water on acetylene (carbide alcohol).

The German government assumed full charge of alcohol production, and it was feared in the industry that this step, which was taken as a war measure, would not be rescinded, but would result in an alcohol monopoly in the future.

This project of an alcohol monopoly was adopted on its third reading by the Reichstag, on July 13, 1918, by the Bundesrath on July 19, and finally promulgated as a law on the 26th of the same month.

In the text of this bill is found some very interesting information on the new processes (b, c and d) referred to in the foregoing. There is no need to refer here to the fiscal character of this law, but the technical appendices will be of interest to our readers, and a translation is here given. Aside from the technical information contained therein, these appendices furnish general indications regarding the economic values attributed to the different methods at the time.

In cellulose plants, the wood pulp is boiled in an aqueous solution of bisulphite of calcium, in order to purify the cellulose contained in the wood, by the elimination of materials with which it is impregnated. Up to quite recently, this bisulphite solution, after it had once served its purpose, was not recovered, but was drained off and often caused great damage.

During the early part of 1900 it was discovered that the waste liquors of German cellulose factories contained a little more than one per cent of sugar, and it was found that from 1,000 cu. ft. of this waste liquor it was possible to recover from 42.5 to 50 gal. of alcohol. These results were verified in 1915 by renewed experiments. The discovery, however, was never put to practical use in Germany, for the reason that the manufacture of alcohol from sulphite waste liquors—in view of the fiscal regulations concerning alcohol then in force—would have yielded no profit. Moreover, the often expressed belief that by the treatment of the sulphite waste liquors for the production of alcohol (that is to say, by the elimination of the sugar content), the delicate question of waste liquor disposal would be solved, was not a sufficient incentive. In Sweden, on the other hand, the manufacture of alcohol from waste liquors was successfully taken up during the year 1909, and in that country there are now numerous plants for the production of alcohol from sulphites.

Under the compelling influences of the war the manufacture of alcohol from sulphite waste liquors was taken up anew in Germany, and the experience gained in Sweden was turned to good account.

The process for recovering alcohol from sulphite liquor comprises three operations, as follows: (1) The preparation of the waste liquor for fermentation; (2) the fermentation of the sulphitic must, and (3) the distillation of the fermented sulphite solution.

Sulphite waste liquors contain, in addition to sulphurous acid, which interferes with the fermenting action of the yeast, acetic acid and formic acid. These acids are eliminated partly by blowing air through the waste liquors, after they have been raised to a temperature of 185-195 deg. fahr., partly by the addition of carbonate of lime and of a little slacked lime. The neutralization must be carried to a point necessitated by the subsequent fermentation. This is accomplished in concrete tanks in which the waste liquor is allowed to remain for some hours in order that it may become clarified. This is followed by another clarification of the liquor from which the mud has been separated, which is accomplished in a reservoir which serves for filling the fermentation vats. The waste liquor is then transferred to a concentration tank cooled by air, in which at the same time it is cooled, saturated with air and concentrated to a certain degree.

Fermentation takes place in tanks of 3,500 cu. ft. capacity, with the aid of a very active yeast, which has been slowly accustomed to the conditions which the fermentation of the waste liquor presents, and which is continually transferred from a tank in which fermentation has been completed, into a fresh tank. The sulphate waste liquor contains insufficient quantities of nutriment for the yeast, and for this reason there is added either ammonium sulphate, or super-phosphate, or, on the other hand, a yeast extract which is prepared in distilleries with waste liquor containing an excess of yeast. The fermentation takes place at 84-85 deg. fahr., and on the average requires 72 hours, producing from 66-72 gal. of alcohol from 1,000 cu. ft. of waste liquor.

The alcohol contained in the fermented waste liquor is eliminated in large distilling apparatuses, in which, on account of the small alcohol must content (0.9 to 0.95 per cent), and on account of the large quantity of liquid to be treated, the application of heat is especially advantageous. The must contains volatile, organic acids, and filters of sodium carbonate must be introduced during the distillation. The distilling apparatus may also receive a charge of a solution of sodium carbonate.

In some plants, the unrectified alcohol obtained from bisulphitic waste liquors still contains a small amount of sulphuric acid. The only thing to distinguish it from unrectified alcohol obtained from potatoes is the small content of methyl alcohol and of aldehyde. Small quantities of fusel oil are also often found in it. The crude alcohol is materially improved by the use of distilling apparatus working on the principle of separating the head, in such a way as to obtain, by the separation of the heads (representing 10 per cent of the total) a sulphite alcohol susceptible of being denatured and the heads purified.

The purification of sulphite alcohol does not present any special difficulty. It should be pointed out, however, that rectified sulphite alcohol still contains a little wood alcohol which can be separated from it only with difficulty. Sulphite alcohol may be employed for all purposes for which potato alcohol is suitable.

If we assume a yield of 10.7 gal. of alcohol per ton of cellulose (which corresponds to 0.9 per cent of alcohol in the fermented liquor), the German sulphite distilleries with the plant installed by them during the war, in one year can furnish 116,000 hectoliters (3,000,000 gal.) of alcohol (corresponding to 1,044,000 metric quintals, or nearly 100,000 tons of potatoes). The total production of the cellulose works working the sulphite process being approximately 600,000 tons per year, in peace-time, by the treatment of all the waste liquors for the production of alcohol, it would be possible to obtain annually

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6,400,000 gal. of alcohol (representing a consumption of 240,000 tons of potatoes). Whether the cellulose factories will extend their alcohol production will depend upon what progress is made with other methods of utilizing waste liquors. The small cellulose works, which during the war could work part of their waste liquors for the purpose of producing glues, did not consider it of sufficient importance to erect plants for the production of alcohol.

COST OF PRODUCTION.

The cost of producing alcohol from sulphite is still undetermined. A diminution of the cost will not be possible until after the fruition of efforts looking towards the concentration of the vinasse derived from the emptying of the sulphite must, and toward the production of methyl alcohol, acetone, acetic acid, and cellulose wax by the dry distillation of this vinasse.

From the remotest antiquity, alcohol has been obtained from the saccharine juices of plants, and from vegetable material containing starch. Experiments with the object of preparing alcohol from cellulose—the carbo-hydrate of the greatest importance next to sugar and starch—were attempted only at a relatively late date. In 1819 it was found possible, by treating cellulose by means of concentrated sulphuric acid, to obtain a fermentable sugar, dextrose. The production of alcohol from the cellulose contained in wood seemed at first an insoluble problem, in spite of numerous researches. Not only does the need of large quantities of sulphuric acid for the transformation of the cellulose into sugar occasion heavy expense, but it also involves great technical difficulties, which are due to the fact that it is necessary to separate the acid from the dilute saccharine solution.

Since 1890, chemists have paid renewed attention to the problem of obtaining alcohol from substances containing cellulose, as is evidenced by the numerous patents issued on the subject during that period. The latter generally relate to the transformation of cellulose, under the influence of a dilute mineral acid, and the majority effect the process in close vessels under pressure. Attempts have been made to saccharize the cellulose contained in peat, either by heating it for a long period in contact with an acid at atmospheric pressure, or by heating it for a short time in contact with an acid under high pressure. The saccharine solution obtained by filtration must be treated with chalk in order to diminish the acidity, and then be submitted to fermentation. For the saccharization of wood and of wood waste, numerous processes have been evolved, which utilize either sulphuric acid, sulphurous acid, anhydrous sulphite or a mixture of these, with the use of steam under pressure. In all of these processes, the sugar derived from the wood should be recovered by drainage. The aqueous saccharine solution should, after neutralization of the acid, be prepared for fermentation. Undoubtedly, this process permits of a yield of 14 to 28 gal. of alcohol per ton of wood in the dry state, starting with wood waste, which up to now was burned as of no value. Nevertheless, in Germany, alcohol derived from wood has not been able to compete with alcohol from potatoes, on account of the excise tax imposed. It is for this reason that none of the attempts in Germany to manufacture alcohol from wood have passed beyond the laboratory stage. On the contrary, in France, England and the United States the manufacture of alcohol from wood has entered the domain of practice. In one plant in the United States, which is said to have an annual output of 500,000 gal., the yield varies from 15.4 to 22.8 gal. of alcohol per ton of dry material.

In Germany a beginning was made in the spring of 1916 in the manufacture of alcohol from wood, with the object of conserving the potato and molasses supply. The Classen process on the one hand, and the process of Windesheim-ten-Doornkaat, on the other, proved themselves best adapted for practical application. By the Classen process the sawdust is heated for 40 min. in rotary caldrons, with sulphurous acid, under a steam pressure of 7 atmospheres (313 deg. fahr.). The steam is then allowed to expand as rapidly as possible, and the saccharized wood must is emptied out into diffusers. The saccharine solution obtained by diffusion is neutralized up to the necessary point in tanks containing an agitator, an addition of table salt is made, and the mass is allowed to ferment in fermenting tanks with pressed yeast, or beer yeast. The alcohol formed is separated in the usual distilling apparatus. With the Classen process one may count on a yield of at least 14.5 gal. of alcohol per ton of dry material. The process has been improved, so that the yield already has been increased to 20 and 25 gal., and it undoubtedly will be still further increased.

By the Windesheim-ten-Doornkaat process, sawdust is heated with diluted hydrochloric acid in the presence of catalizers (metallic salts), in rotary caldrons, under a pressure of 7 to 8 atmospheres (330-340 deg. fahr.) for 20 to 30 min. The final treatment of the saccharized sawdust is the same as that already described. This process, which is probably subject to improvement, yields a minimum of 7.2 gal. of alcohol per 1,000 lb. of wood in the dry state.

The alcohol production plants under construction will work according to these two processes. The choice between the two will depend upon the kind of acid most available, and upon the alcohol yield which will be obtained. Germany produces from 500,000 to 1,000,000 tons of sawust, susceptible of being treated for the manufacture of alcohol. The alcohol factories possess a total of 51 caldrons capable of handling one ton of dry material each. By working day and night, each caldron can handle 10 batches of material daily, or—figuring on 350 working days a year—3,500 batches yearly. That is to say, working to full capacity, it will be possible to treat 178,500 tons of wood annually on the dry basis, or 238,000 tons of sawdust. If one figures on a yield of 14.4 gal. of alcohol per ton of dry material, a total production of 2,570,000 gal. of alcohol per year is arrived at, which is equivalent to the yield from 106,000 tons of potatoes. If the yield can be raised to 24 gal. of alcohol per ton of dry wood, as is to be expected, the production of alcohol will amount to 4,190,000 gal. (corresponding to 176,000 tons of potatoes).

It is still impossible to give any data regarding the cost of producing alcohol from wood. It is certain, however, that it is much higher than that of alcohol from sulphite. The production of alcohol from wood can become commercially practical only if the wood acted upon, when deprived of its sugar, can be utilized as feed, or rather if it should prove possible to obtain from it acetone, wood alcohol and other products of dry distillation. The necessary research work has not yet been carried out, and at present the only use that can be made of the heat value of the residue of the saccharized wood, is to use it as fuel under the boilers in the alcohol plants.

The unrectified alcohol obtained from wood contains as impurities small quantities of aldehyde, wood alcohol, "furfurol" and fusel oil. The rectification of the alcohol, however, presents absolutely no difficulties. Inasmuch as the raw alcohol made from wood, on account of its low alcohol content, cannot be denatured, and therefore cannot be employed for industrial uses, purification readily yields an alcohol which is sufficient for the requirements of powder manufacture. It is still necessary to determine experimentally whether the recovery and commercial utilization of the by-products, such as furfurol, will not permit of reducing the cost of producing alcohol from wood.

MANUFACTURE OF ALCOHOL FROM CALCIUM CARBIDE.

When lime and coke are heated to the temperature of the electric furnace, about 5,000 deg. F., a new chemical compound is obtained—calcium carbide. Of all the numerous carbides known, the carbide of calcium is industrially of by far the greatest importance, and for this reason it is gen-

erally called simply carbide. It is decomposed by water, forming acetylene, with a residue of lime. If acetylene is introduced into a heated, diluted acid, in the presence of a mercury compound, aldehyde (acetaldehyde) is formed, the components of water being fixed upon the carbide. Aldehyde is a very volatile combustible liquid, of penetrating odor, which combines with hydrogen in the presence of certain metallic catalizers, such as nickel, producing ethyl alcohol (grain alcohol).

As the acid used and the mercury compounds or other metallic catalizers are not modified in the process, or in any case are capable of being returned to their initial state with only small loss, and as the hydrogen may be produced with coke and water, this method of manufacturing alcohol requires only coal, limestone and a rather small amount of heat.

In the manufacture of alcohol from carbide, the following expenses are incurred: 1—Manufacture of carbide; for 1,000 gal. of alcohol it is well, in the present state of the art, to count on approximately 6.5 tons of carbide, for the production of which 24,000 kilowatt hrs., 8 tons of coal and 12 tons of limestone are necessary. If cheap power is obtainable in the neighborhood, as, for instance, water power, or power obtained from cheap fuels, such as lignite and peat, the cost per kilowatt-hour may be as low as 2 pfennigs; in that case, the power cost for 1,000 gal. of carbide may be set down at 240 marks. The cost of the raw material, charcoal and limestone, is approximately 60 marks; the cost price of carbide previous to the war in Germany was 112 to 115 marks per ton. Experience indicates that these figures represent the lower limit, and this statement is corroborated by the figures previously given. As far as can be judged at present, small plants, or those not favorably situated, could not produce at this figure. What the price of carbide may be after the war can only be conjectured. It should be pointed out, however, that the cost of packing for the retail trade, which must be of such a character as to prevent all moisture from reaching the carbide, which cost is not appreciable, need not be considered here, and that the overhead expenses connected with the manufacture of carbide at wholesale need not play a very important part. Moreover, the amount of 2 pfennigs per kw. hr. does not seem to be the minimum at which power can be delivered in Germany.

2—The manufacture of acetylene from carbide does not involve any special expenses for other raw materials, for the decomposition of carbide is effected by means of water, and the purification of the gas is effected by different purifying masses of which some are cheap in themselves, while others are capable of being regenerated, among these latter figuring compounds of copper, chrome and lead, as well as of chlorine and lime. The yield to be expected is 80 gal., equivalent to 0.35 lb. of acetylene per pound of carbide of good quality.

3—The following operation, that is to say, the transformation of acetylene into aldehyde, does not involve the consumption of any important amount of raw material, but does involve the consumption of a large amount of energy. Up to the present, it involves only slight losses. The yield, according to information furnished by the plants (of which none has been in operation for any great length of time) is at most 90 per cent.

4—A most important item in the final operation, the production of alcohol, is the consumption of hydrogen. In order to obtain 1,000 gal. of alcohol, it has been calculated that it is necessary to consume at least 53,000 cu. ft. of hydrogen, which can be obtained at about 2.25 marks per 1,000 cu. ft., this low price being made possible by the low cost of the raw materials, in spite of the expensive installations necessitated for production and purification.

Assuming that all conditions are favorable, that is to say, that the location of the plant is wisely chosen, and that operations are conducted on a sufficiently large scale, one may count on a cost price of 900 marks per 1,000 gal. of alcohol, equivalent to 90 pfennigs per gal., this including the cost of raw materials. To this must be added something for depreciation of plant, salaries, etc., items which are rather difficult to estimate in advance. The purification of the alcohol obtained should not present any greater difficulties than the purification of alcohol obtained by fermentation. As a result of the method of preparation, it does not contain any secondary product of fermentation known under the name of fusel oil; on the other hand, it may contain some sulphuric, phosphoric and arsenic combinations and certainly there will be aldehyde and substances derived therefrom. The best samples so far presented to the government represent a fine industrial alcohol which can be used in most industries.

PRICE CALCULATION.

The preceding price calculations are confined to a certain extent by the conditions of a contract under which a Lonza (Switzerland) concern has engaged to furnish alcohol obtained from carbide to the Swiss government. The price of the rectified alcohol, according to the contract, is to be 1,330 marks per 1,000 gal., the Federal administration taking delivery at the plant in its own tank cars. From a certain point of view, the operating conditions of the plant at Lonza should be better than could generally be obtained in Germany. Undoubtedly this plant gets its power at less than 2 pfennigs per kw. hr. Near the great waterfalls in Norway, there are large plants which obtain power at approximately 0.5 pfennig per kw. hr. On the other hand, the contract was closed on the basis of high cost of coal (36 marks per ton). The cost price of the Lonza plant (which is a private enterprise) may be estimated at a little more than 110 marks per 100 gal. of alcohol.

It should not be lost sight of that such calculations are subject to numerous causes of error, which are difficult to estimate. If, for instance, the cost of the kw. hr. becomes greater than that previously given, as may easily happen in certain parts of Germany, if the yield of aldehyde or alcohol is a few per cent less than that assumed, or if the renewal of the carbide furnaces occasions greater expense than that provided for, and, finally, if the royalty to be paid on the patent is added, the cost price of alcohol from carbide may come somewhat higher than that arrived at above. A private corporation, which has carried on experiments on a small scale, has reached the conclusion that alcohol derived from carbide cannot easily compete with alcohol of fermentation, even if taxation should be the same.

The process outlined above is so far the only one which has been applied on a large scale. However, it is not the only one theoretically possible. One may also conceive of a process in which no aldehyde is produced, but only ethylene, by the addition of hydrogen to the acetylene. It is an easy matter to pass from ethylene to ethyl alcohol, by a process which has been known for a long time. This has recently been more closely investigated, but it is not yet possible to give any information regarding its success.

Plants already in existence in Germany for the manufacture of carbide and those whose construction has been decided upon, will furnish annually from 400,000 to 450,000 tons of carbide, when operating to full capacity. After deducting the quantities of carbide necessary for lighting, for metallurgical operations, etc., there remain nearly 400,000 tons for fertilizer or for alcohol, and this would produce 66,000,000 gal. of alcohol.

It remains to be investigated what influence the calcium cyanamide obtained from carbide may have on the production of potatoes, and thus on the production of alcohol.

One pound of carbide when heated with nitrogen furnishes 1.25 pounds of calcium cyanamide, containing approximately 20 per cent of nitrogen, and considering that it is customary to count on a gain in yield of 100 pounds of potatoes per

pound of fixed nitrogen in the fertilizer, the use of one pound of carbide for the manufacture of nitrogenous fertilizers would result in a gain in production up to 25 pounds of potatoes, equivalent to 0.133 gal. of alcohol; that is to say, more than four times the amount of alcohol which may be obtained directly by chemical process.

On the other hand, if one considers that calcium cyanamide is now the lowest priced fertilizer, and that the growing of potatoes usually has a very favorable effect upon the following other crops, the direct manufacture of alcohol from carbide cannot be considered seriously until the agricultural demands for nitrogenous fertilizers in Germany have been satisfied in some other way, and filled at an adequate price. On the other hand, it is possible that there will not be a demand for a long time for all of the fertilizer that can be produced by the German plants utilizing carbide. Calcium cyanamide has this disadvantage that the caustic dust is very annoying when it is being spread, and that its fertilizing action depends, more than for other nitrogenous fertilizers, upon the nature of the soil, the atmospheric conditions, the nature of the plant, and the method and time of use. The German demand for nitrogenous fertilizers in the next few years may be estimated at between 1,500,000 and 2,000,000 tons per year. The yield in ammonium sulphate of the German coke ovens may be estimated at approximately 500,000 tons, and this may be increased. In fact, it is likely that the production of ammonium sulphate at the coke works will be increased to 1,000,000 tons within a few years. Whether it will be possible readily to sell from 500,000 to 600,000 tons of fertilizer, in the form of calcium cyanamide, will depend in the first place upon the price, and also upon the competition created by the importation of saltpeter from Chile, and from Norway, and other fertilizers which are technically perhaps even more advantageous. Under the first head, we have to do here with ammonium compounds, and with their derivates prepared by the Haber process, the entire supply of which at the present is under government control. If the nitrogenous fertilizers, which are relatively cheaper than those obtained from carbide, should be set free again, the result would be that the large German factories of carbide and calcium cyanamide would have to look elsewhere for a market for their products.

SELECTIVE ABSORPTION AND ITS RESULTS.

Various investigators both in this country and abroad have been recently engaged in studying the curious phenomenon known as selective absorption. The results of their researches are interestingly summarized in *La Revue Générale des Sciences* (Paris), as follows:

It is a well-known fact that various colloids absorb the free base of the salts dissociated by hydrolysis in their aqueous solution more rapidly than the acid. They redden litmus by absorbing the blue base. In a solution of a blue salt whose free base is red these colloids absorb the red base and acquire a red color meta-chromatically.

Basophilous colloids are found in histological compounds such as cotton fibers and pectic membranes and in cytological compounds; they also occur in soils (in clay and in humic substances) and likewise in deposits of baregine, etc.

The so-called acid earths owe their property of reddening litmus paper at least in part to basophilous colloids, includthe humic substances, clays, silicates, and oxides of iron. The basic jellies on the contrary, which include the oxides of zirconium, thorium, aluminum, lanthamium, zinc, beryllium Be iron, and chromium absorb the acid of the dye known as Congo red; when they are heated in the presence of a solution of Congo red they exhibit the red color characteristic of salts (6). This explains why thermal waters (the waters of Barèges) restore upon boiling the red color of solutions of Congo red which have been turned blue by acids, with a precipitation of the *insoluble blue acid* which is an isomer of the red acid of the Congo.

By reason of their power of selective absorption certain colloids are capable of being employed as reagents for analytical purposes, being capable of separating the different ions of electrolytes in solution and of isolating certain substances which it is very difficult to isolate chemically. In living creatures we may explain by the theory of a selective absorption which varies in accordance with metabollic conditions, why it is that the nuclear chromatine sometimes fixes the blues (basophilous nuclei) and at other times the reds (acidophilous nuclei).

In nature there occurs "a struggle for bases" between the basophilous colloids of plants and those of the environment: thus the basophilous Zoögleae of the baregines demineralize thermal waters; the Diatoms (*Synedra*, etc.) possess beneath their siliceous shell a thin membrane, which is capable of fixing metallic bases even upon the living creatures; many absorbent hairs come in contact with the soil by means of a basophilous pectic membrane. Finally, the tissues which succeed in reacting successfully against parasitic infection exhibit a marked basophily which it is possible may oppose the migration of the bases of the host into the parasite.

The mediums which retain bases strongly, acid soils, will support only forms of plant life which are especially adapted to them, such as the *Vaccinium corymbosum*, etc., unless bases be added to them in the form of lime in excess of their basophilous power of absorption.

ARTIFICIAL DAYLIGHT.

An English artist and designer, Mr. George Sheringham, recently exhibited before the Society of Illuminating Engineers, in London a remarkable device for producing the exact effect of daylight, a problem which there have been many efforts to solve. His apparatus aroused much interest and was extremely successful in producing the illusion of white light.

The apparatus itself consists of a large shade on whose under surface is a design in colors carefully worked out to agree with a definite mathematical formula governing the proportions. Upon the surface thus colored the light from an electric bulb is projected in such a manner that all the rays strike the shade and are diffused into the surrounding atmosphere. The transformation into white light or "daylight" thus secured is made possible by the skillful choice, proportion, and arrangement of the various colors employed. By this means the excess rays from the red end of the spectrum are absorbed, and *apparently* (so far as the sensation upon the optical nerve is concerned) the rays towards the violet end, which are ordinarily deficient in artificial light.

Mr. Sheringham first constructed the apparatus in a very simple form and employed it for his own studio work in the fall of 1918. Some time afterward it was exhibited to Major Klein, advisor in the physics of color to the Calico Printers' Association of England, and former chief of the experimental department of the British Camouflage School. Major Klein was at once struck with the potential importance of the invention with respect to all those industries such as dyeing, painting, frescoing, etc., which employ color. He realized, however, that the apparatus could not be definitely accepted until it had been scientifically tested, adjusted, and improved. He, therefore, called on Mr. L. C. Martin of the Optical Department of the British Imperial College of Science for assistance in perfecting Mr. Sheringham's invention. The success of these two collaborators in rendering the original device more effective is generally conceded by all who have seen it in operation. Whereas blues and greens seen by an ordinary incandescent light have their intensity diminished to about one-ninth and one-half respectively, under the Sheringham light they shine out as brilliantly as the reds. Delicate shades of grays and blues are easily perceived and navy blue shows in its true color instead of looking black. A point which will be of special interest to artists is that tones of yellow very elusive to ordinary light can be as readily distinguished as in bright daylight.

Electric Starting Systems for Automobiles

Various Ways in Which Electric Motors and Generators are Employed in Modern Motor Cars

By F. C. Barton

EVER since the early development of the explosion or internal combustion engine, it was realized that the inherent drawback to the use of this type of prime mover lay in its inability to be started by energy stored within itself. The problem of starting the engine with the least expenditure of human energy has therefore occupied a large place in the minds of designers, with the result that various forms of starters were devised.

There were straight mechanical devices employing springs or their equivalent to give the initial impulse; then, too, there were devices in which the internal combustion engine by the use of special distributor valves was converted into a compressed air engine, taking air under pressure from a storage flask. This flask was in turn charged by some form of pump connected to the engine and driven by it during periods of normal operation. There were gas devices in which an explosive charge of acetylene, or other gas, was introduced through suitable distribution valves directly into the cylinders and was there exploded by the usual electric ignition.

Almost without exception these devices lacked reliability. The springs did not store enough energy to make second and third attempts at starting in case the first failed. The air starters developed leaks and pump troubles which resulted in the slow discharge of stored air with attendant loss of starting ability. The gas starters were always "touchy" and frequently the mixture introduced for starting would not ignite when the spark was applied, and, when it did ignite, the resulting explosion was apt to be of greater violence than is desirable from a mechanical standpoint.

There were also electrical starters, which took energy from a storage battery to drive an electric motor mechanically connected to the engine, the battery being recharged by an electric generator driven by the engine during normal operation. Other things being equal, the type of starter using electrical energy acquired a tremendous advantage over all others by reason of the possibility of combining starting with the most satisfactory form of lighting, viz., that employing Mazda electric lamps. Furthermore, it might be combined to furnish energy for the now extensively used battery ignition. Hence, electric systems always include starting and lighting, and, frequently, starting, lighting and ignition.

It is not the purpose of this article to discuss either lighting or ignition systems, but to give a brief outline of the various ways in which electric motors and generators are employed in modern automobile design and construction.

Electric starting and generating sets may be divided into three general classes, as follows:

First: The single unit system in which the same electrical machine acts as both motor for starting and generator for charging the battery.

Second: The two unit system in which the motor is employed for starting only, and is not in use for any purpose except during the starting period. The generator is used only for charging the battery, and is an entirely separate unit driven independently by some means from the engine during normal operation.

Third: A combination of the two systems already mentioned. This system usually includes a single field structure and an armature having two windings and two commutators, one being employed when the machine is operating as a motor, and the other when operating as a generator.

The single unit system requires an electrical and mechanical compromise. The mechanical reduction ratio between the armature of the machine and the engine crank shaft must be such that the speed of the armature will not be dangerous when the engine is driven at speeds equalling maximum car speeds. These engine speeds may be in the neighborhood of 3000 r.p.m. or above. It is therefore advantageous, from the generator standpoint, that the driving ratio be as low as possible but, from the motor standpoint, where a high torque is required at the crank shaft, it is desirable to keep this ratio as high as possible, as the lower the ratio the larger must be the electrical machine to accomplish a given result. The electrical compromise lies between the speed at which the machine will crank as a motor and that at which it will charge the battery as a generator.

The combination-unit system employs a single field structure and a double wound armature. In this system the armature shaft is usually extended through both ends of the machine, the rear end being connected through suitable gearing to the engine fly-wheel (upon the periphery of which gear teeth are cut) during starting operations. After starting, the mechanical connection to the engine flywheel is disconnected, and the armature of the machine is then driven by means of the forward shaft extension from a suitable power take-off on the engine arranged to drive the armature as a generator at a suitable speed.

To accomplish the change-over from motor action to generator action, various automatic or semi-automatic mechanical devices are necessary. These usually consist of a manually operated gear shifting device and switch, for engaging the motor reducing gears with the flywheel gear and completing the electric circuit to the motor winding, and an over running clutch on the generator drive which permits the armature to rotate free from the generator drive while it is running as a motor cranking the engine, but which will cause the armature to be driven by the engine when the starting gears are disengaged and the motor circuit broken. This arrangement permits the motor ratio to be selected independently of the generator ratio.

The two-unit system employs a motor and a generator, the generator being driven through an ordinary coupling, or by chain or gear by the engine, the motor being connected automatically, or by a manual shift, to the flywheel gear ring during starting operation.

The means employed for making the mechanical connection between the motor shaft and the engine flywheel has been the subject of a great deal of engineering development. At this date, by far the greatest number of devices make this connection and disconnection automatically. These automatic "shifts" consist, in almost all cases, primarily of a pinion connected by some means to, or made part of, a nut which runs on a screw thread mounted on, or cut in, an extension of the motor armature shaft. When the motor circuit is closed, the armature starts to rotate, but the pinion and nut, because of their inertia, remain almost stationary. This causes the lead screw on the motor shaft to propel the pinion forward toward the flywheel in a direction parallel to the axis of the shaft until it encounters and engages with the flywheel teeth. Contact between the edges of the flywheel and pinion teeth checks any tendency the pinion may have had to acquire the rotative action of the armature, thereby causing the lead screw to propel the pinion positively to the limit of its travel. It then can travel no further axially and must, therefore, either stop the armature or rotate with it, and, being in mesh, if it rotates, it must also rotate the flywheel and thereby crank the engine. As soon as the engine commences to run by its own power, its speed is sufficiently great, with relation to that of the motor, for the pinion to be driven by the engine faster than the screw shaft is driven by the motor.

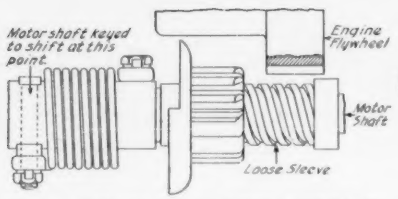


FIG. 1. SPRING DRIVE SHIFT (INBOARD)

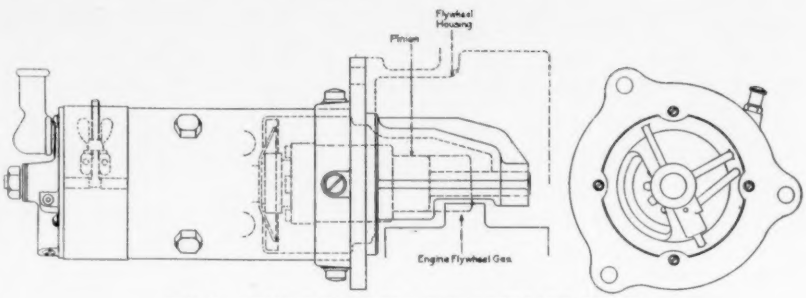


FIG. 3. STARTING MOTOR FOR OUTBOARD SHIFT

This causes the action of the lead screw to be reversed, and the pinon is therefore propelled by the engine back along the motor shaft to the out-of-mesh position. At this point the motor circuit should be broken. If it is not, it merely continues to accelerate until free running speed is reached, but as the pinion is then running at approximately the same speed as the armature, there should be little tendency on its part to re-enter the flywheel gear.

The foregoing merely outlines the fundamental actions of engaging and disengaging. A description of details, such as the method of absorbing shock, and the prevention of reentry, and the obtaining a correct angle of entrance follow.

INBOARD AND OUTBOARD SHIFTS.

Generally speaking, there are two types of automatic screw shifts in extensive use. One transmits the torque developed by the motor to the pinion through the medium of a coil spring wound around the shaft. The other delivers the motor torque to the pinion through a self-tightening friction clutch.

The object of ether the spring or the clutch is to minimize the shock that would take place when the pinion reached the end of its travel on the lead screw on the motor shaft, or the point at which its axial motion is translated into rotative motion. It must be remembered that the rate of acceleration of the motor armature is very high, and by the time it has rotated the necessary one or two revolutions, which carries the pinion into mesh, its angular velocity is great enough to damage the gear teeth or armature shaft if the shock at the instant of starting to crank is not cushioned in some way.

These devices are also designed to minimize the liability of encountering what is known as a "butt." This means a condition where the flywheel teeth and the pinion teeth are not so lined up that they can slide directly into mesh. In other words, a pinion tooth may strike end on against a flywheel tooth, and, without some flexibility in the drive, will not be able to enter, and the two will then lock tight in what is commonly known as a "jam."

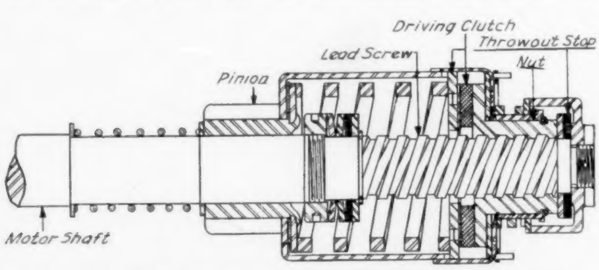


FIG. 2. CLUTCH DRIVE AUTOMATIC SHIFT (INBOARD MESH)

To reduce further the possibility of a "jam" at the front end the pinion teeth are chamfered to produce the smallest frontal area, and still maintain a liberal mechanical margin of safety against breakage. This chamfering is very similar to that used on transmission gear teeth, where it is done for the same purpose.

The flexibility of drive also provides against another condition known as "hunting." This condition is particularly in evidence with four cylinder engines, and is a result of the reaction of gases compressed in the combustion chambers of the cylinders by the pistons on their compression strokes. The expansion of each compressed charge, on what would be the working stroke of the cycle if the charge were fired, causes the engine to tend to over-run the starting motor, which in turn tends to run the motor pinion out of mesh. The two factors which prevent this from actually taking place are the flexibility of the drive and the high rate of acceleration of the motor, which enables it to keep up with quite violent changes in angular velocity. The tendency to "hunt" decreases as the number of cylinders is increased, until, with a twelve-cylinder engine, the torque required by the engine for starting is, due to overlapping of power impulses, almost uniform throughout a revolution.

When the engine fires, causing its sudden acceleration from cranking speed to running, the motor pinion, as previously explained, is run back along the lead screw to the out-of-mesh position. This throw-out is frequently quite violent; therefore, some form of cushion stop or detent is provided at the out end of the screw to prevent the possibility of a rebound of the pinion, which might bring it into contact with the flywheel again, and, owing to the relatively high speed of the flywheel such contact might cause serious damage to the gear teeth.

Another point, which is given consideration, in "shift" design, is "angle of entrance." Normally, the pinion is approximately ⅜ of an inch away from the flywheel when out of mesh. While travelling this ⅜ of an inch along the lead screw and being restrained from turning only by inertia, a certain amount of rotative movement is acquired. Experiment has demonstrated that a definite amount of rotative movement is desirable, and reduces the liability of "butt," and that this amount is usually in excess of that which would be normally acquired; therefore, some form of friction clutch, or loading device, is provided to give "initial" friction between pinion and lead screw to give the desired number of degrees of rotation.

Two forms of each type of automatic shift are used; that in which the pinion is propelled rearward away from the starting motor when going to mesh, this being known as "outboard" mesh, and that in which the pinion in normal position is to the rear of the flywheel gear, and is therefore propelled forward toward the starting motor into mesh. This latter is known as "inboard" mesh.

Car builders who manufacture their own engines and clutch housings usually provide for inboard shift, as such changes as are necessary are purely internal matters with them, and can be easily provided for. But manufacturers of assembled cars purchasing engines and gear sets, which usually include clutch housings, almost invariably use the outboard form of shift.

The shift description has been carried out to some length, as it is a very vital part of the whole system, and, while fundamentally simple, has undergone much re-design and development to bring it to the present position of reliability and sturdiness.

STARTING MOTORS.

Starting motors are always straight series wound and of very low internal resistance, both as to windings and brushes. This is necessary to meet cold weather conditions when the battery voltage is low and the current demand is high. Under these conditions the current necessary to turn over a stiff engine may be three or four hundred amperes, which means only 3.5 to 4 volts at the motor terminals. This voltage is used up in two ways: first, in overcoming brush and brush contact drops and winding resistance, and, second, in the production of useful work. So whatever fraction is saved from the former is available for the latter, thereby improving the performance of the motor.

The conditions outlined in the preceding paragraph will be found only in extremely cold weather, but they must be met if the starting is to be successful at all times.

Fig. 4 gives characteristic horse-power, speed, and torque curves of a 4 7/16-inch diameter Bijur motor. With this curve as a base, the most desirable ratio of pinion to flywheel to give the most satisfactory cranking can be determined. It is of course to be desired that when conditions are adverse, viz., when the engine is cold, the motor speed shall be such that it will operate as nearly as possible at the peak of its horse-power curve, that being the point at which it will do the most useful work.

Take, for example, a six-cylinder engine of a size suitable for the moderate-sized car. This engine will have a displacement of 303 cubic inches or cylinders 3½ by 5¼ inches, and a flywheel having 126 teeth. We know that this engine will require about 30 lb.-ft. torque at the crank shaft to crank when hot, and that it will need three to four times that torque to crank at zero or below, and that under this severe condition the cranking speed must not fall below 50 r.p.m.

By a cut-and-try method it will be found that a nine-tooth pinion will be suitable. The ratio will be 126:9 or 14:1, or at 50 r.p.m. crank shaft will give a motor speed of 700 r.p.m. 700 r.p.m. = 8.6 lb-ft. torque or 120 lb.-ft. at engine crank shaft will take 400 amp. and deliver 1.2 h.p. which is near the peak of the horse-power curve, and, therefore, at the most desirable point. This is satisfactory for cold performance.

To find what will happen with a warm engine requiring only 30 lb.-ft. at the crank shaft or 2.12 lb.-ft. at the motor shaft, read straight up from the 2.1 torque point. It equals 135 amp., 2080 r.p.m. or 147 r.p.m. crank shaft and 0.82 h.p. which is satisfactory.

GENERATORS.

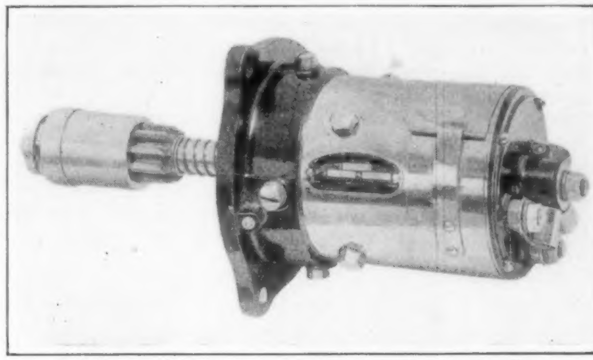
The principal factor in determining the size of generator suitable for a given car is the ratio between the driven speed of the generator and the miles per hour of the car. This factor is usually given in terms of revolutions per minute of the generator per mile per hour of the car. This is affected by:

First: the road wheel diameter.

Second the rear axle ratio.

Third: the ratio of the generator drive to the crank shaft.

This last ratio is usually determined by the number of engine cylinders, as the generator drive is in almost every instance made to run at a speed suitable for magneto drive. This would be 1:1 for four cylinders and 1.5:1 for six cylinders.



STARTING MOTOR FLANGE MOUNT (INBOARD SHIFT)

For example: A four-cylinder car having 33-inch wheels and a 4:1 rear axle ratio and a 1:1 generator to crank shaft ratio would have a generator speed of 41 r.p.m. at 1 m.p.hr. If this happened to be a six-cylinder car and the generator to crank shaft ratio was 1.5:1, the generator speed would be 61.5 r.p.m. at 1 m.p.hr.

Experience has shown that a generator to meet average conditions should delver 10 amp. at a car speed not much in excess of 14 m.p.hr. and should give maximum output at some speed between 20 and 25 m.p.hr.

The choice of a generator, therefore, is merely a matter of selecting a standard machine which will fulfill the current output conditions outlined above at the speed available at 14 m.p.hr.

Take the six-cylinder example for illustration. A generator having an output like the curve Fig. 5 would be satisfactory. This machine delivers 10 amp. at almost exactly 860 r.p.m., which equals 61.5 × 14, or 14 m.p.hr. car speed. It reaches a maximum of between 16 and 17 amp., at 1400 r.p.m. equaling 23 m.p.hr.

After the maximum output has been reached a further increase in speed causes the current rate to fall off. This falling off of the charging rate at high speeds is a most

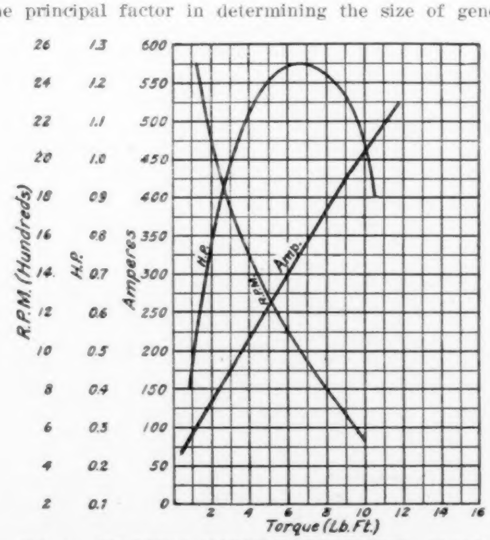


FIG. 4. STARTING MOTOR HORSE-POWER, SPEED AND TORQUE CURVES

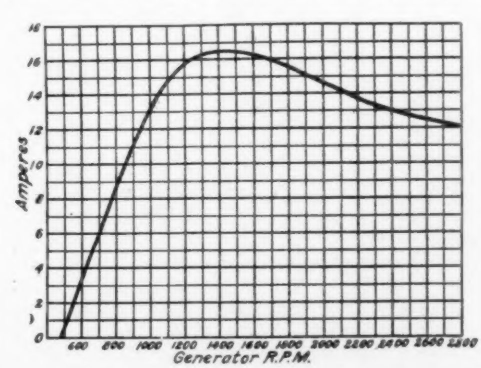


FIG. 5. BATTERY CHARGING CURVE, THIRD BRUSH GENERATOR

desirable feature of a generator employing the third brush type of regulation, as it means that the average city driver, who operates at low speeds but who uses the greatest amount of current for lighting and starting, gets the highest charging rate, whereas the tourist or country driver, operating over longer periods of time and at higher average speeds than the city man, gets a lower rate of charge which saves his battery from heating and loss of electrolyte due to the decomposition of the water when gasing.

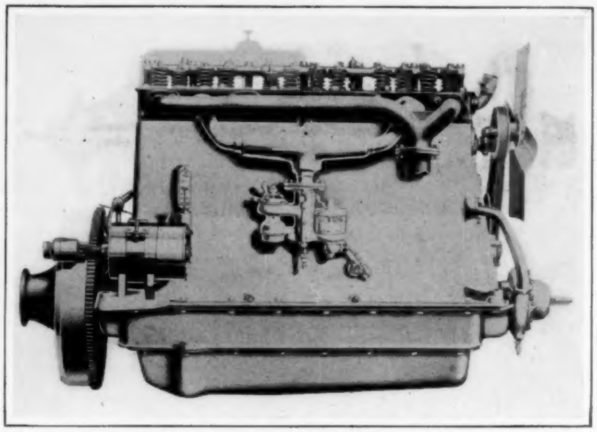
The foregoing remarks on charging rates relate to the current regulated or third brush type of machine. This is the type most extensively used on moderate and low-priced cars. One other system of regulation is in fairly extensive use, especially among the higher-priced cars. It is the system employing voltage control. The feature of this method of control is that it supplies a high current when the battery is low, and a low current when it is high. It approximates what is known as a "taper" charge or one in which the generator if connected to a discharged battery will deliver a high rate at the start of the charge, but as time progresses the rate will gradually fall until, at the end of the charge, it is down almost to zero.

This system usually includes a straight shunt-wound generator which builds up to a voltage equal to that necessary for the maximum charging rate at comparatively low speed and some form of vibrating voltage regulator whose function is to hold constant generator voltage. This is done by alternately cutting an external resistance in and out of the shunt field circuit. Its rate and period of vibration depend upon the speed at which generator is being driven and the battery current requirements.

TAPER CHARGING.

The voltage regulated or constant potential system of battery charging, which gives a tapering charge, Fig. 6, is based on the fact that the counter electromotive force or opposing voltage of a battery is lower when the battery is discharged than when it is charged. The difference will be in the order of 0.6 volts per cell, or for a 3-cell 6-volt battery will be 1.8 volts. Therefore, if the generator is set to hold 7.8 volts, equalling a fully charged battery, it will have, with a discharged battery having a counter electromotive force of only 6 volts, 1.8 volts available for forcing the charging current through the battery; consequently, the charging rate will be high. Leaving the regulator and generator characteristics out of consideration, the high current rate will be determined by Ohm's law, where E or voltage is the difference between generator voltage and battery counter electromotive force and R or resistance equals the sum of the battery and external circuit resistances. If $E = 1.8$ and $R = 0.06$, then the charging rate to the battery will be $1.8 \div 0.06 = 30$ amp. at the start. The rate will taper to zero when the charge is complete, at which point the battery counter electromotive force equals the generator voltage.

In actual practice this condition is only approximated, that is, the regulator or generator, or both, may be so designed that the inital rate will be lower than the rate indicated by the foregoing formulas, and the final rate will not be zero, but rather something of the order of 5 or 6 amp. This is done to prevent the generator from being excessively overloaded during the first part of the charge, and to make sure that the battery will receive a low rate overcharge after completion of the regular charge.



INBOARD MESH STARTING MOTOR

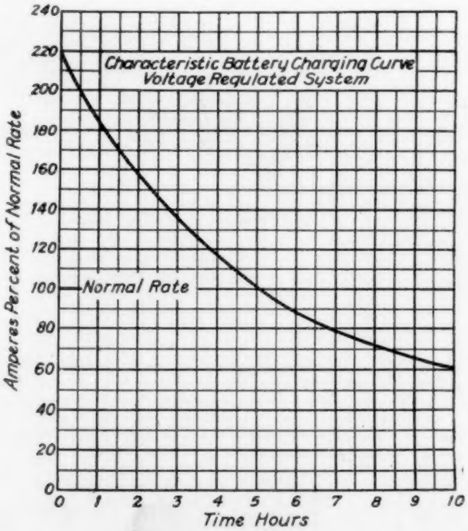


FIG. 6. CHARACTERISTIC BATTERY CHARGING CURVE, VOLTAGE REGULATED SYSTEM

TERMINALS.

Car builders in many instances do not give the subject of connections and terminals the consideration that it should have. Terminals should be rugged to withstand vibration, and should so hold the cable that the effects of vibration at the point they are attached will also be minimized. Terminals should always be soldered to cables, but the solder should never extend beyond the last point of support of the cable; in fact, it is preferable that the terminal be so designed as to support the cable by means of a clamping band which encircles the insulation at a point beyond the bared portion to which the solder is applied. Above all, terminals should be tight on connection boards, as loose terminals mean extra resistance, and extra resistance in the lamp or ignition circuits means decreased brilliancy of lights or unreliable ignition. In the generator circuit of a third brush machine, extra resistance means increased generator voltage with attendant heating of the generator; and in the generator circuit of a

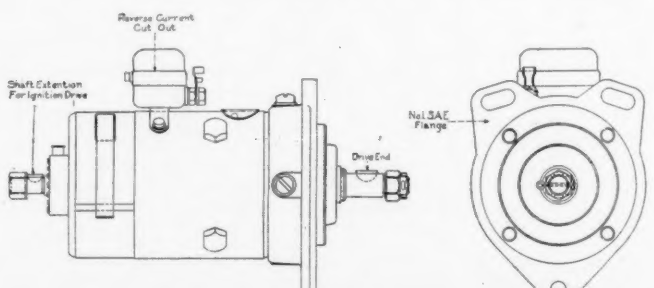
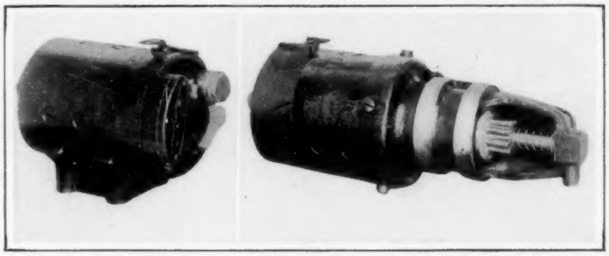


FIG. 7. DESIGN OF GENERATOR FOR FLANGE MOUNT (S. A. E. FLANGE DESIGN)

voltage regulated machine means decreased current output to the battery.

SOCIETY OF AUTOMOTIVE ENGINEERS.

The work of the Society of Automotive Engineers toward the standardization of all parts of the automobile has been of great value in simplifying and standardizing the mounting of electrical apparatus. The Society through the medium of its standards committees has recommended for adoption by manufacturers: three methods of mounting starting motors; two methods of mounting generators; one form of pinion and gear tooth.



GENERATOR FOR BRACKET MOUNT STARTING MOTOR FOR SLEEVE MOUNT (OUTBOARD SHIFT)

The three mounts are:

First: for inboard flange mount with three sizes of flange.
Second: for outboard flange mount with three flange sizes.
Third: for outboard sleeve mount. This is only one size.

In each of these, all dimensions which affect both motor and engine manufacturers are given. Roughly, these are: flange bolt drilling and location of holes; diameter of pilot; distance from flange face or dowel screw to flywheel teeth; and height of flywheel teeth above flywheel proper.

The gear and pinion tooth selected is of standard 8-10 pitch 20 deg. pressure angle.

The generator mounts are:

First: flange with two sizes to accommodate large or small machines.

Second: bracket with but one size laid out to accommodate the largest generator that may reasonably be encountered.

The flange method of mounting is employed when the generator is driven direct by a gear or sprocket running in the engine timing gear case. The engine half of the flange mount is then machined on the rear face of the gear case. The bracket mount is used where a separate shaft is brought out of the timing gear case for driving the water pump, ignition apparatus, or generator, or sometimes two or all three of them. In this case, the generator is mounted on the engine bracket and driven by means of a flexible coupling.

In these layouts, as in the motor layouts, all common dimensions are given, incuding shaft and sizes, coupling fits, and height of shaft above bracket, and in the case of the flange mount, shaft end sizes for gears or sprockets and drilling and shape of flange.

UNBALANCED FORCES IN RECIPROCATING ENGINES.

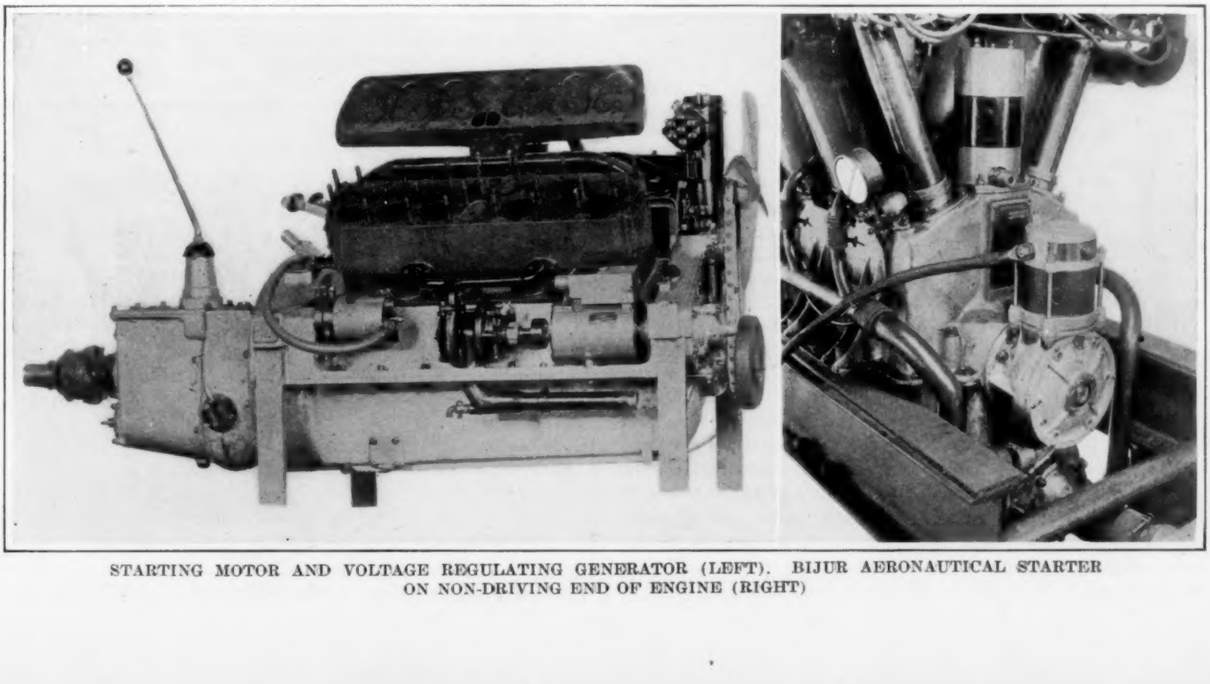
WRITING in *The Automobile Engineer* for February, 1920, J. L. Napier treats with great detail the unbalanced forces at every 5° of the crank position of the engine, and takes into account all the various types and groupings of cylinders, from the 4-cyl. vertical engine to the "broad-arrow" type, with three groups of four cylinders.

The author considers all unbalanced forces which tend to vibrate the engine as a whole to be transferred by stresses internal to the structure of a single plane at right angles to the center line of the crank-shaft.

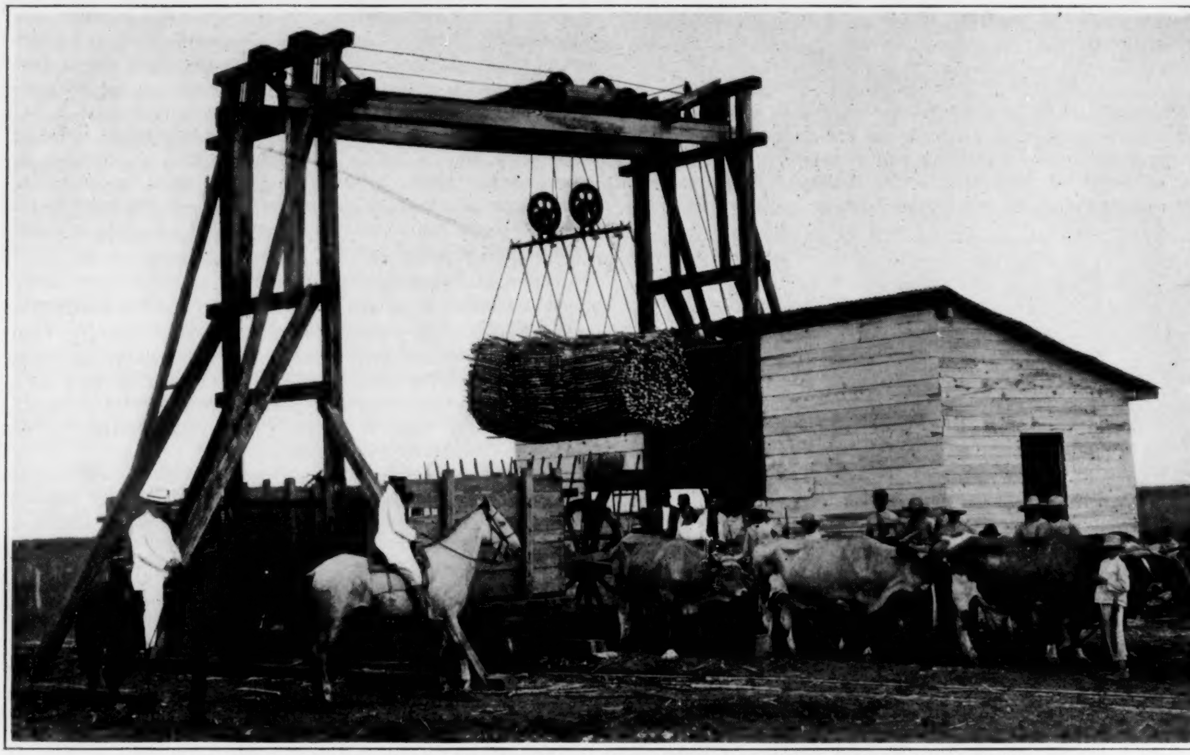
The principal source of unbalanced tangential forces is the fluid pressure of the gas in the cylinders, and the principal source of unbalanced radial force is the inertia of the reciprocating masses. Interesting tables are given which allow curves to be plotted showing the piston acceleration, the unbalanced vertical force, and the torque due to inertia, with varying lengths of connecting rods. Concerning the "perfectly-balanced" six-cylinder engine, the author remarks that one is prone to ignore the effect of the tangential compound of inertia force in causing angular vibration of the engine about the crank-shaft center; the effect of inertia on torque is quite as considerable in the six-cylinder engine as in the four, but can be minimized by increasing the connecting rod length.—Abstracted by *The Technical Review.*

HIGH-SPEED RADIO-TELEGRAPHY.

IN a test of high-speed radio transmission between Woolwich and Weymouth in which the messages were recorded in Morse code and in printed Roman characters, 2,017 words were sent in 30 minutes, 901 words in 8 minutes and 379 words in 4 minutes. The speed was limited only by the exigencies of mechanical design.—*Royal Engineer's Journal*, Feb., 1920.



STARTING MOTOR AND VOLTAGE REGULATING GENERATOR (LEFT). BIJUR AERONAUTICAL STARTER ON NON-DRIVING END OF ENGINE (RIGHT)



TRANSFERRING A BALE OF CANE FROM AN OX CART TO A RAILWAY CANE CAR, IN CUBA

Electrification of the Hershey Cuban Railway

A High Voltage Direct Current System

By F. W. Peters

At all large Cuban sugar mills, railroads for transporting cane extend in various directions to tap the areas where cane loading stations are located. Two-wheeled ox-drawn carts are used to gather cane in the fields and haul it to the loading station where it is placed aboard especially constructed cane cars which are later made up into trains and hauled to the mill. The necessity of grinding cane shortly after it is cut, in order to obtain a maximum sugar yield, renders desirable the maintenance of a reliable railway system to supply the mill with a continuous flow of cane, thereby eliminating "cane shortage" shut downs which prove so costly to the sugar operator.

The industry has assumed such proportions that the mills command attention not only for their size, intensive operation, and efficiency, but also for the supplementary industrial activities necessary to the support of the mills during that five-month period of 24-hours per day cane grinding when nothing but a break down or an important holiday is deemed sufficient cause to stop operations.

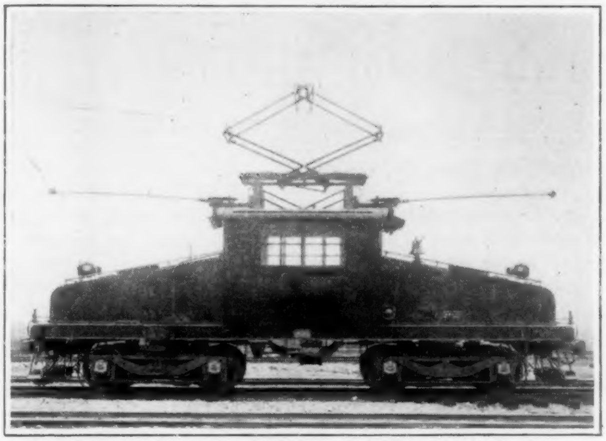
Hershey Central, a beautifully situated town overlooking the Gulf of Mexico, is located on the north coast of Cuba practically midway between the cities of Havana and Matanzas, some 56 miles apart. The major activity, at this as well as numerous other Centrals on the island, is the manufacture of sugar. This mill is now served by the Hershey Cuban Railway, a steam operated road having approximately 55 miles of single track. The present motive power consists of seven steam locomotives ranging from 20 to 40 tons on drivers. Both coal and oil fired types are in use, which on account of the very high cost of fuel in Cuba and the inefficient operation of such engines constitute an expensive item in overall operation and preclude an efficient expansion of traffic such as outlined herein.

In keeping with the broad plans of the management, the road is being electrified, and extensions which will comprise the main line are being completed to Havana on the west, and to Matanzas on the east. Branch lines between Havana and Cojimar, 4½ miles, between the main line and Bainoa, 7½ miles, and between the main line and Santa Cruz, 4½ miles, are completed. These with numerous short spurs and

MAP SHOWING ROUTE OF THE HERSHEY CUBAN RAILWAY

sidings will total 80 miles of electrified single track. The road is built over a private right of way through a rolling country in which the ruling grade is 2½ per cent. The track is standard gage with 85 lb. per yard running rails, rock-ballasted over the greater portion.

The service to be maintained upon inauguration of electric operation will consist of cane and sugar transportation besides through and local commodity freight, express service, and multiple unit passenger train service operating on one-hour haedway between Havana and Matanzas.



A 60-TON, 1,200-VOLT DIRECT CURRENT LOCOMOTIVE

The 1200-volt direct-current electric railway system was selected by the railroad management after a thorough investigation of various types of electrified roads, as being that which would fulfill to the best advantage the present conditions of electrical operation as well as provide for efficient expansion incident to anticipated growth.

LOCOMOTIVES

The motive power furnished for operating the foregoing cane and general freight service consists of seven 60-ton four-motor 1200-volt direct-current electric locomotives arranged for multiple unit operation when necessary. The control provides for connecting the motors in series or series-parallel, and consists of two master controllers (one located at each driving position in the main cab) with resistors, dynamotor blower set, solenoid contractors, and other auxiliaries mounted principally under the end cabs. Power for operating the control equipment is obtained at 600 volts from the dynamotor. A pantograph type trolley is mounted on top of the main cab with provision for the convenient use of pole trolleys, to provide for operation over adjoining electric railways necessitating such type of trolley. Combined straight and automatic air brake equipment is used with two 35-cubic foot displacement per minute air compressors placed in the main cab and operated directly from the 1200-volt trolley wire.

MOTOR CAR EQUIPMENT.

The motor car equipment consists of ten straight passenger cars, three combination passenger and baggage cars, and two combination express and mail cars. The passenger cars seat 50 persons, having a free running speed of approximately 40 miles per hour, and will weigh completely equipped about 29 tons. Four motors per car are provided with automatic electro-pneumatic double-end multiple unit control equipment arranged to connect the motors in series and series parallel. Power for the control circuits and car lighting is obtained from a 32-volt constant potential generator driven by a 1200-volt direct-current motor operating from the trolley circuit. Pantograph type trolley and bases for pole trolleys are mounted on the car roof.

POWER GENERATING AND SUB-STATION EQUIPMENT

The power equipment selected to operate the railroad and to furnish commercial power to Matanzas and smaller towns along the right of way comprises a generating station, one main railway sub-station and two outlying automatic sub-stations. The generating station is equipped with three 2500-kva. turbine alternators and has four 600 hp. oil-fired steam boilers.

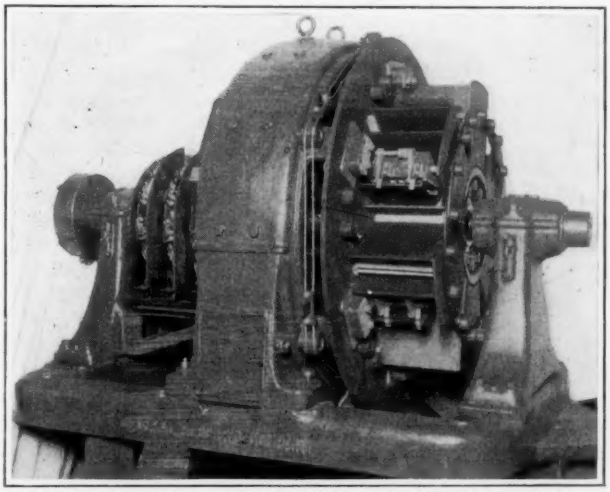
The main generating voltage is 2300 three-phase 60-cycle from which step-up transformers between the main 2300-volt bus and the high-tension bus distribute power at 33,000 volts three-phase to the outlying sub-stations and points of commercial distribution. Power for station auxiliaries and shops is obtained from transformers stepping down from 2300 to 480 volts. This latter voltage, largely used in sugar mill work, was selected to permit a direct tie-in when necessary with the main bus of the sugar mill power house which is close to, but distinct from the new railway station.

The railway synchronous converters located in the main station consist of two groups in parallel, each group comprising two 500-kw. 600-volt machines connected in series for 1200 volts. These receive their power from the main 2300-volt station bus through step-down transformers.

For oil firing a steam atomizing system is used with exhaust steam surface heaters arranged to heat the oil to the right viscosity for proper atomization. Two 7500-gallon capacity auxiliary fuel oil tanks are located near the boiler room, each of which holds approximately one day's supply based on the estimated load for the near future, while some distance away are the main oil storage tanks having a 500,000 gallon capacity. No attempt was made to utilize bagasse, the refuse from ground cane, as fuel for the railway power station since the quantity produced by the grinding rolls is practically all consumed by the sugar mill boilers.

Provision has been made for conveniently installing coal burning machinery without disturbing the boiler settings or auxiliaries should a readjustment in the relative price of coal and oil necessitate the use of coal for economy.

A spray pond constructed of concrete is located 600 feet distant from the power house and is connected by two 36-inch



A 500-KW. 600-VOLT SYNCHRONOUS CONVERTER USED IN THE SUBSTATIONS—NOTE THE FLASH BARRIERS

concrete pipes, one of which connects to the intake and the other to the discharge wells, in the generating room, used for the condenser circulating water. Three motor-driven 4600 g.p.m. high efficiency pumps which force the discharged circulating water through the spray nozzles are located in the pump house at the spray pond.

SUB-STATIONS

The two outlying automatic sub-stations, one of which is located near Havana and the other near Matanzas, are duplicates and each contains one 1000-kw. group of synchronous converters consisting of two 500-kw. 600-volt machines con-

nected in series. A third 500-kw. 600-volt spare converter is provided with change-over switches so that it may be conveniently substituted for either the high or low machine of the group. Three 350-kva. single-phase 33,000-volt high-tension self-cooled transformers having double secondary windings are regularly employed for operating the converters with a fourth transformer supplied as a spare. The switching equipment is completely automatic in operation and is similar to those which during the past few years have proven very successful in many parts of the United States. No regular attendants are required for the operation of the equipment since it starts automatically on a power demand and stops when the demand ceases. During operation the equipment is protected from injury due to excessive overload by the use of flash barriers and load limiting resistors on the direct-current side of the machine. All irregularities emanating from disturbance on the high-tension lines or improper functioning of the equipment is fully protected against so as to promote reliable operation. Two feeder circuits leave each sub-station to allow the trolley and line feeder cable to be sfectionalized in front of each station.—Abstracted from *General Electric Review*, April, 1920, pp. 307 to 312.

Future Developments of the Rigid Airship*

Methods of Utilizing Excess Hydrogen

By Squadron Leader P. Litherland Teed, R.A.F.

Now that the dawn of the English Commercial Airship era is breaking, it is appropriate to point out that there are fields of technical development which commercial enterprise must investigate to secure reductions in the cost of airship operation.

The first subject for investigation is hydrogen economy.

When an airship flies it decreases in weight by the amount of gasoline and oil consumed, or, in other words (if the secondary effects of superheating and super-cooling of the hydrogen are for the moment neglected), it can be said that the airship increases in buoyancy or lift to an extent which is a function of its *horsepower hours* of flight.

The airship engine may be taken to consume 0.53 lb. of petrol and oil per horsepower hour, consequently taking as an example an airship of the German L-30-39 class, these ships which are of 1,300 horsepower will increase in buoyancy by:

$0.53 \times 1{,}300 = 689$ lbs. per hr. of full power flight.

To prevent the airship's rising from this continually increasing buoyancy during flight is simple; in the early stages of flight the tendency to rise can be counteracted by the elevators, but with lapse of time the ship becomes so light that this ceases to be an effective remedy and it is then necessary to decrease the lightness of the ship by releasing hydrogen. Now since, for reasons of controllability, it is necessary when landing an airship at the end of a flight that the airship should be in equilibrium (i.e., equal in weight to the weight of air displaced), it is ultimately necessary to valve hydrogen equal in lifting power to the weight of the gasoline and oil consumed during the flight.

To put this statement into definite terms is simple. On an average, 1,000 cubic ft. of hydrogen has a lift or buoyancy of 65 lb., consequently

0.53 lb. will be lifted by $\frac{1{,}000 \times .53}{65} = 8.2$ cu. ft. of hydrogen.

Thus there is a hydrogen consumption from this cause of 8.2 cu. ft. per hp-hr. of flight, or applying this to the L30-39 class of Zeppelin, this type of ship will be ultimately forced to release hydrogen equal to:

$1{,}300 \times 8.2 = 10{,}660$ cu. ft. per full power hour of flight.

To express this waste of gas in money in these days of fluctuating prices and rapidly improving efficiency in the technology of hydrogen production is difficult, but it is non-controversial to say that the total cost of hydrogen in England, including labor, insurance, depreciation, material, etc., is at present approximately 15 shillings per 1,000 cu. ft., consequently the airship taken as an example will consume: $10.7 \times .75 =$ £8 worth of hydrogen per hr. of full-speed flight, which is a serious charge, but one ultimately preventable provided sufficient inducement is given to engineers to deal thoroughly with the problem.

There are at least three methods whereby increase in buoyancy, with its present attendant unnecessary hydrogen loss, can be dealt with.

(1) Water recovery from the engine exhaust.

(2) Picking up water from the sea.

(3) Burning hydrogen (a) to produce water, (b) to produce power.

Water Recovery from the Engine Exhaust.

Gasoline, which is a mixture of various hydrocarbons may be taken, for the purpose of this note, as being represented by the formula, C_7H_{16}, therefore the complete combustion of a mixture of gasoline vapor and air in the cylinders of an airship engine can be expressed as follows:

$$\underset{\text{Gasoline}}{C_7H_{16}} + \underset{\text{Air}}{11\,(O_2\,4\,N_2)} = \underset{\text{Carbon dioxide}}{7\,CO_2} + \underset{\text{Water}}{8\,H_2O} + \underset{\text{Nitrogen}}{44\,N_2}$$

But the molecular weight of gasoline is 100 and that of water 18, therefore it can be deduced from the above equation that: 100 lb. of gasoline produce on combustion $(8 \times 18) = 144$ lb. of water.

Thus the weight of water passing as steam out of the exhaust pipe of a gasoline engine is nearly one and a half times the weight of the gasoline entering the carburetor, so, if effective means were evolved of condensing this steam by cooling the exhaust gases below the boiling point of water, it would be possible to maintain an airship in a state of approximate equilibrium during flight *without the loss of hydrogen.*

At first sight it might be said that the above is the solution of the problem of hydrogen economy during flight, but, though it may be, it is at present not much more than the outline of a procedure which by careful attention to detail may be developed in a practical process for commercial airships.

Among the difficulties of this procedure may be mentioned the quantity of heat to be absorbed; the exhaust gas of a gasoline motor contains about the same quantity of heat as is normally dissipated by the radiator of the engine, consequently, the cooling of the exhaust by this means would increase the head resistance of the ship and would also be subject to objection on the grounds of additional weight.

Another difficulty is the actual catching of the water; after the exhaust has been cooled below the boiling point of water (if the vapor present is neglected), the volume of the water particles is about 0.01 per cent of the volume of the exhaust gas, therefore, to prevent these water particles from being carried out of the exhaust pipes, the particles in the exhaust gas require considerable surface to which they may become attached.

While it is not difficult to recover water from the exhaust of internal-combustion engines—it has been done several times in the case of Diesel engines, running in the desert to make up cooling water losses—it is difficult to do so in airships without somewhat heavy apparatus, which, besides the objec-

*From *Aeronautical Engineering* (supplement to *The Aeroplane*), March 31 1920, pp. 677-8.

tion of weight, has the additional disadvantage of increased head resistance, but attention to design will reduce both these objections considerably, and it may well be that hydrogen consumption from increase in buoyancy may be reduced by the method outlined above.

PICKING UP WATER FROM THE SEA.

Since the commercial utility of rigid airships lies chiefly in long-distance trans-oceanic flight, increase in buoyancy might be dealt with by picking up sea water from time to time equal in weight to the gasoline and oil consumed.

A method whereby this can be achieved consists in forcing the airship under power to within 400 ft. of the surface of the water and then dropping a streamline vessel like a paravane, which is connected to the airship by a fabric hose; the streamline body with the necessary stabilizing surfaces is fitted with a water propeller at its stern, which, by being towed through the water, drives a reciprocating pump within the paravane delivering via the fabric hose into the ship.

This device can be made within a reasonable weight to deliver a ton of water in five minutes with a satisfactory mechanical efficiency, but its employment in the future seems problematical, as at present it has not the approval of pilots for two main reasons, one of which is the intermittent operation of the device combined with the necessity for very careful control of the ship during its operation, and the other is that in fog when the surface of the water cannot be seen, the risks of attempting to fly at this low altitude are too great to allow of using the apparatus.

BURNING HYDROGEN TO PRODUCE WATER.

To burn hydrogen to save hydrogen seems at first paradoxical, if not absurd; but an examination of the facts will show that the procedure has certain points in its favor. Water contains one-ninth of its weight of hydrogen, or, in other words, one part by weight of hydrogen on burning in air makes nine parts of water. Confining the examples for the development of the argument to approximations, if under the econditions prevailing 1,000 cu. ft. of hydrogen weighs 5 lb., then, on burning this volume of gas in air, 45 lb. of water will be produced, which, it is assumed, at this stage, will be satisfactorily condensed in the ship.

Now, under average conditions, 1,000 cu. ft. hydrogen would give a lift or buoyancy of 65 lb., therefore, by burning 1,000 cu. ft. of hydrogen, and condensing the resulting steam, the airship would decrease in lift by

$$65 + 45 = 110 \text{ lb.}$$

so it is seen that instead of having to valve 8.2 cu. ft. of hydrogen per hp-hr. of flight, by burning hydrogen and collecting the water only

$$\frac{1{,}000 \times .53}{110} = 4.8 \text{ cu. ft.}$$

would be lost per hp-hr. of flight in order to keep the airship in equilibrium. Thus the paradox "to burn hydrogen is to save hydrogen" is established.

An advantage claimed for this method is that the effective recovery of the water would be easier as the percentage of water in the products of combustion would be greater than in the exhaust of the gasoline engine; after these products have been cooled to below the boiling point of water (if the presence of water-vapor is neglected) they would contain 29 per cent of water by volume instead of the 0.01 per cent contained in the exhaust of the gasoline engine under similar conditions.

It is probable that the process just outlined could be more rapidly applied with success to airships than the first method which was described. However, this last process has only the potentiality of reducing the present waste of hydrogen but not of stopping it.

BURNING HYDROGEN WITH THE PRODUCTION OF POWER.

The burning of hydrogen to save hydrogen is a wasteful process (though it would do much to stop the present more wasteful procedure), for weight for weight hydrogen has three times the calorific power of gasoline, so that 1,000 cu. ft. of hydrogen, since it weighs about 5 lb., is equal in calorific value to 15 lb. or 2 gal. of gasoline. Therefore, if hydrogen equal in buoyancy to the weight of gasoline consumed were burnt in an engine, the airship besides remaining in continuous equilibrium (except for secondary effects) would have a greater speed for the same gasoline consumption, or an equal speed for a smaller gasoline consumption.

It has already been shown that 8.2 cu. ft. of hydrogen has a lifting power equal to the weight of gasoline and oil consumed per hp-hr.; now assume that this 8.2 cu. ft. of hydrogen is burnt in a special internal combustion engine of the same efficiency as the present gasoline engine, the power developed will be:

$$\frac{8.2 \times 5 \times 3}{1{,}000 \times 5} = .25 \text{ hp.}$$

That is to say, if an airship is constructed to develop 80 per cent of its power by gasoline engines and 20 per cent by means of a hydrogen engine the ship will (except for secondary effects) remain in constant equilibrium during the whole period of its flight, or, in other words, the maximum endurance of an airship so fitted with a hydrogen engine would be 25 per cent greater than that of a ship similar, except for the whole power being developed by gasoline engines.

Examining the economics of this scheme, if gasoline costs 2s. 6d. per gal, and hydrogen 15s. per 1,000 cu. ft., the cost of power produced by hydrogen is over two and a half times more expensive than when produced by gasoline (assuming equal thermal efficiency in the gasoline and hydrogen engines). However, since in the present method of operating airships this hydrogen is entirely wasted, and in the suggested method it increases the maximum endurance of the ship by 25 per cent, it must not be rejected on economic grounds.

Examining the technology of this scheme, since the velocity of explosion of hydrogen and air mixtures is enormous (when compared to gasoline and air mixtures), it is probable that the moving parts of a hydrogen engine would have to be more massive than those of a gasoline engine of the same power, that is to say, a hydrogen engine would be a heavy engine on the basis of weight per hp. Confirmatory of this, it may be mentioned that in his recent lecture to the British Association on Airships, Wing Commander T. R. Cave-Brown-Cave stated that, using an ordinary airship engine with hydrogen as the fuel, the maximum power output was 25-30 per cent of that obtained from the engine running on gasoline; attempts to obtain large power output produced serious cylinder detonations.

Owing to the difficulties (not necessarily unsurmountable) of making a light hydrogen engine, V. Bellamy has invented an ingenious device whereby a very weak gasoline and air mixture is re-enforced with hydrogen to such an extent as to give gasoline economy and, at the same time, full power output from the engine. Since this device has all the advantages obtainable from using hydrogen as a fuel, it is probable that in the future it will be considerably employed. Though it does not effect hydrogen economy it may be said that, because it allows a higher commercial load to be carried by an airship (owing to reduced gasoline consumption), it has potentiality of doing rather more, as it increases the maximum revenue obtainable from freights, and reduces the actual fuel cost of transporting that freight.

ULTRA-VIOLET LIGHT TEST FOR BALLOON FABRICS.

THE deterioration of balloon fabrics is supposed to be due to the action of heat, light and moisture. It is believed that ultra-violet in sunlight is one of the chief factors and in order to obtain an accelerated aging test the experiment was recently tried of exposing fabrics to a mercury vapor arc. The tests were not conclusive.

SOARING OVER THE CRATER OF MOUNT LASSEN, CALIFORNIA

A Pack Train of Eagles*

Suggested Use of Aircraft in Mining Operations Where Roads and Trails Are Absent

By Eugene Shade Bisbee

A CERTAIN mining company had received several reports from different engineers about a property in a remote part of Idaho. Practically all of the reports were in favor of the property, which the company seriously considered buying. As a final precaution the president sent a young mining engineer to report. After a month or more, this telegram was received: "Vein all right; sample correct; ore is there. To get the stuff out would take a pack train of eagles." This story was told a long time ago, and the acumen of the young engineer was admired, his reference to a "pack train of eagles" exciting a hearty laugh wherever the story was told. Times have changed. What then appeared an absurdity has now passed beyond the air-castle stage. A "pack train of eagles" may not elicit much surprise in the mining industry in the course of a few years. In this day of keen competition the man who says "It can't be done" wakens some morning to discover that somebody has done it.

I have shown before the value of the airplane in preliminary mining operations, the saving of time and money and the greater accuracy of the work. Since that article appeared several American airplanes have been put to work in Peru; and down in Mexico an American mining operator has petitioned the Carranza government for permission to use an airplane in his work. Therefore, it has been demonstrated that aircraft possess a unique usefulness in this field. They not only can be used to survey and map the significant area, but also to carry men in and out and to transport supplies, material, and high-grade ore. They are destined to play a part in mining development, but they will co-ordinate with the prosaic mule in transportation and never wholly replace him in certain fields that are all his own. In fact, if a mine needs the services of an extra mule it will be the airplane that will carry the mule in, transporting the animal fifty times as fast as his own sure feet would take him there and taking his feed along to boot. For the airplanes that are going to be used in mining will be built to carry not less than 1,200 lb. of useful load.

For this new work both the airplane and the dirigible will be used, as the lighter-than-air craft needs less landing space than the plane, and will, generally, be called upon to transport the more bulky freight, leaving the lighter packages, the high-grade ores and bullion for the speedier plane. In carrying vanadium, uranium and radium ores at present from Paradox Valley to Placerville, in Colorado, four-horse teams are used, and from two to four days are required for the trip of about seventy miles. An airplane would take 1,000 lb. of the ore, winter or summer alike, over the mountains, in less than an hour, making not less than half a dozen trips a day and keeping it up, regardless of ground conditions of snow, ice, land-slides, or anything else, as continuously as may be necessary. Returning to the mine from the railroad shipping point, the airplane can take in men and emergency supplies; it will take the superintendent or other officials back and forth on business; it will keep the operators in continuous touch with both ends, thus making for higher efficiency and greater production and rapid delivery of the product to the base of final disposition.

Very rich ores may be transported in small compass, but an airplane will carry in four days—the time required by a horse or mule team to go one way—not less than twelve times the weight or ore brought out by the animals during

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a like period of time. And it must not be overlooked that it will make twelve return trips, taking in all kinds of necessary supplies or men.

Although it has been said that the airplane will never entirely supersede the mule or the horse in the field where those animals have been pioneers, certain comparisons between draught and pack animals and the airplane throw an interesting light by contrast. After the location has been made by airplane exploration, and the mosaic maps have been prepared and the ore uncovered, tools, men, and supplies must be sent in. The lighter of these tools and supplies can be transported by plane, the heavier by team. Consider the saving of time by the assurance that every bit of smaller machinery, every tool, all supplies, and every man, will be on the ground and ready for action by the time the heavy material has arrived by mules, because they have been taken in by plane, at a speed more than twenty times that of the animals that plod over the rough ground, while the plane darts to and fro above them; the whole circumambient blue being its magnificent roadway. Dwell for a moment upon the toiling string of llamas that pursue their course down the slopes of the Andes, their backs laden with precious ore. All day long they trudge onward, urged by their drivers, who, by the way, are ever careful not to get within "spit-shot" of an irate llama. For there are at least two things that start a fight in South America; one is a llama that believes itself to have been abused, the other is a man whom the llama believes has abused him and into whose eye, from a distance of fifteen or twenty feet, the llama has violently spit. The insult is eradicable only by the near-death of the llama, which can only be saved by the interposition of someone in authority.

While the llamas are covering the distance from the mine to the railroad or seaport the airplane is ever speeding above, back and forth, with mineral and supplies, and even men, doing every day the combined work of not less than thirty llamas, and neither complaining of treatment nor spitting in one's eye!

Statistical details may be made less uninteresting by showing that a pack train of sixty mules can carry approximately, 24,000 lb. some twenty-odd miles over mountain roads in a day of eight hours. Six men will be required to drive sixty mules, and six men will draw, again approximately, $36 per day in wages. Add to this the cost of the rations for the men and the animals. For the last named the cost will be, based upon the present price of oats and hay at Atlantic tidewater, $1.06 per day, as a healthy, hard-working mule will need sixteen quarts of oats and twenty pounds of hay daily, if you expect the animal to work. The men will eat up more money, if not an equivalent weight in food.

While the mule train is making its twenty-odd miles per day, with 24,000 lb. of useful load, the airplane is hurrying to and fro at eighty miles an hour, as against the three miles of the mules, and taking with it on each trip about 1,200 lb., or at the rate of a round trip from the mine to the railroad and back, the distance being assumed to be twenty miles, in half an hour, not allowing for time to load and unload. During a day, therefore, the plane could carry back and forth over such a line sixteen loads of 1,200 lb. each, or something better than half of what sixty mules could transport. At the end of the second day the plane would have equaled the work of the sixty mules for the first day, and from then on there would be no contest—just a runaway for the plane.

Considering the cost of the two factors in this work, the mules and their drivers would consume more than one hundred dollars per day in food and wages; the plane would eat up 160 gallons of gasoline and the pilot would cost $10 each day. Depreciation of both airplane and mules is not considered, but both depreciate proportionately in value as carriers.

The Andes in South America offer a suitable field for the use of aircraft. There are not many roads and there are few trails. Both prospecting and development could be served in almost inaccessible situations. Tools and food supplies could be brought in at a saving in time and with a sureness that could not be equaled by any other means. Bolivia, Peru and Brazil embrace considerable areas of promising mineral ground, it may be conjectured, but much of it is inaccessible on account of absence of roads and trails. The Chilean nitrate fields could have been reached by exploring parties in no better way than by airplane.

The west coast of Mexico, the Sierra Madra country, and other parts of Mexico, indifferently served by roads, present an inviting field to the prospector-aviator.

The Arctic regions, Canada and northwestern Canada, Siberia, China, and Africa are countries in which ordinary means of transportation and travel are indifferent or almost wholly inadequate. The desert regions of Australia form a vast area presenting possibilities for exploration by flying machines.

As an example of the excessive time consumed in certain features of mine-examination work, mention may be made of a copper region east of the Mackenzie River, in northwestern Canada. It possesses many of the characteristics of the Michigan copper country. To visit this region and complete an examination would require two years, one year to go in and another to come out. With an airplane it is probable that the trip could be made from Dawson in a day's time.

There are certain inherent limitations on the use of airplanes and dirigibles. Both are dependent upon a gasoline supply. In the case of using such appliances in prospecting, the conditions are much the same as would apply to an ocean steamer with but a single base for its fuel supply. The maximum outward trip mileage is equal to but 40 per cent of the fuel supply. This leaves only a 10 per cent margin on both the outward and return voyages. Further, it would indicate that, if the gasoline supply in the case of an airplane would be sufficient for 500 miles at economical speed, and with a normal load of freight and passengers, the extreme safe radius of action would be 200 miles. Thus, from a given center of gasoline supply, the area included within a circle of 400 miles diameter could be served. With a mileage supply of gasoline equal to 1,000 miles, the radius would be 400 miles, and the area, a circle of 800 miles' diameter.

By establishing a supplementary supply point and dividing the trips into pairs, one for extra gasoline transport to the supply point and the other for freight service, the trip in any one direction could be doubled. This computation is based on the assumption that the weight of gasoline carried as freight would be equivalent to the 500 or 1,000 miles assumed respectively for such case. These figures assure to a considerable extent that territory within a practicable distance could be served, although special arrangements would be necessitated for trips from 500 to 1,000 miles in length. These would, of course, require gasoline-supply points at suitable landing places en route. The handicap would be the necessity of bringing gasoline to the supply points. By employing two machines, one could be used for supply stations with gasoline and the other for freight and passenger service.

With the use of airplanes, the practical difficulty would be to find suitable landing places. Necessarily, the first trip would be the most hazardous, but after marking and mapping the landing points, the continuation of service would not be supremely difficult. It is worthy of note that in regions containing a number of lakes, as is the case in many parts of Canada, the hydroplane would be especially adapted for utilizing the lakes for landing places.

In the case of the "blimp" or dirigible, the radius of action would be greater and would admit of reasonably close calculation. There would be a nice division between fuel weight and freight weight. Once a definite route had been established, the proportions of freight and gasoline would be constant. As in the case of airplanes, longer voyages could be attempted by establishing supply stations. As the dirigible could land in a limited area, the pioneering trip of the dirigible would be less hazardous than that of the airplane.

The weak point of the dirigible is the difficulty of adequately protecting it at terminals. Some kind of a structure would be required, at least at the starting terminal, and, where established service ensues, also at the distant terminal. Unlike the airplane, the dirigible could travel at night. The expense of a terminal shed would be almost prohibitive.

Probably the most vital question would be the one of safety, and, after that, the cost. The construction of both airplanes and dirigibles has advanced to the point where both types are safe structurally and mechanically for normal conditions. The danger lies in operation and abnormal weather conditions. Experienced operators could undoubtedly be obtained, and by confining actual flying to periods when weather conditions are suitable the risk could be minimized. Transportation through the air would probably never be as safe as ordinary travel. Hidden defects in mechanical equipment might easily force landing in unsuitable and dangerous places; particularly so where it is proposed to use such devices over mountainous country, as would most certainly be required in prospecting. A highly specialized class of skilled labor would have to be employed, and, for service over a long period, an organization with headquarters and repair shops would be necessary.

The cost of operation, as previously indicated, would be high, but in the aggregate it is doubtful if it would exceed the cost of trails or roads. A 100-mile trail at $500 per mile would equal $50,000; a wagon road of the same length at $2,000 per mile would be $200,000. Road and trail cost would of necessity be comparatively figured in any actual case. Considering the saving in time, as pointed out before, the number of cases where flying machines could be used for prospecting and development would not be negligibly small.

Already the airplane is a common sight in the oil fields of the West, and the skies of California are never clear of its gauzy wings. It has conquered the Atlantic and is about to venture the Pacific for a $50,000 prize. Airplanes are no dream; they are one of the hardest of hard facts; they are the carriers, the fleet messengers, the fighting wasps and the unconquerable servants of man, who has created and harnessed them. Soon they will swarm in every sky, and the mining man who has not adopted them for his purpose will compare with the farmer who, on his way to market with his horse-drawn produce, is passed by the other chap in the motor truck, on his way home with the cash in his pocket.

RECENT PROGRESS IN THE INVESTIGATION OF THE UPPER LAYERS OF THE ATMOSPHERE.*

By Dr. K. Scholich.

Even at the very beginning of systematic observations of meteorological phenomena, early in the previous century, the significance of the occurrences in the upper layers of the atmosphere was recognized. However, meteorologists were long obliged to confine their observation merely to the trend followed by the clouds. It was not until the turn of the century at the beginning of our modern conquest of the air, when the necessity for information concerning the atmosphere became indispensable, that methodical investigation of the upper atmosphere was instituted.

Pilot balloons have been of especial service in this respect, whether sent up empty for the purpose of the rapid measurement of high winds or whether provided with registering apparatus so as to furnish data with regard to air pressure, temperature, and humidity of the upper regions of the atmosphere. These rubber pilot balloons possess the great advantage of making their entire upward journey with a constant vertical velocity, as was proved by Hergesell. The information obtained from pilot balloons with regard to atmospheric phenomena has been enlarged particularly in Germany by means of kite ascensions.

During the late war both sides experienced the necessity of placing the military weather service upon as broad a basis as possible. It was particularly necessary to provide the air service with exact data concerning the air currents in the middle layers of the atmosphere. Because of the blockade Germany found herself short of rubber for the making of pilot balloons and, therefore, employed as a substitute paper made air tight to a certain degree by means of suitable impregnation. These balloons naturally did not possess the unlimited ascensional power of the rubber ones, but since they were able to attain an altitude of about 6,000 meters they were sufficiently servicable for the needs of the air service, and because of their greater cheapness they will doubtless be employed for practical weather service even during times of peace.

The rapidity of ascent of the paper balloons is, however, not the same at all heights as it is in the case of the rubber balloons; consequently their course must first be determined by empirical methods. Afterwards it is sufficient to observe the ascent of the balloons from a given point.

A very great disadvantage was experienced in the determination of wind conditions under a cloudy or rainy sky, and this was a serious matter, particularly for the artillery. The French were the first to obviate this difficulty by the ingenious method of sending up a pilot balloon provided with a number of melinite cartridges arranged in a row along a fuse in such a manner as to explode at given intervals during the ascent. The resulting detonations were received in sound meters and these acoustic signals were evaluated by means of simple graphic methods similar to those employed for optical signals during fine weather. In this manner it was usually possible to make measurements of the velocity of air currents up to an altitude of 7,000 meters. The kite measurements previously made as a usual thing attained only very moderate heights.

Because of the discontinuation of meteorological information over the domain of the Atlantic Ocean, the prediction of storms was made considerably more difficult for the Central Powers. On this account it was more necessary than it was previously to obtain and make use of information concerning the distribution of temperatures, humidities, or air pressures in the upper layers of the atmosphere. Since, however, kite stations require not only an extensive provision of apparatus but even more a skilled staff, and the latter cannot be quickly trained, difficulty was experienced in rapidly increasing such stations. On this account recourse was had to flying apparatus as a substitute for kites. These were furnished like the kites with registering apparatus and succeeded in securing the desired data. Furthermore, the art of photogrammetry, which made excellent progress during the war, was impressed into service of the weather bureau. It is quite possible by taking records of two points at a certain distance from each other, to determine the height and also (an especially important point) the angle of inclination of cloud strata. This method is especially valuable for the investigation of the otherwise almost inaccessible stratum of the lofty cirrus clouds, and it is precisely in this stratum that the processes of circulation are of supreme significance as regards the origin of storms upon the surface of the earth.

*Translated for the *Scientific American Monthly* from *Umschau* (Frankfurt-on-Main).

NEW USE FOR ABANDONED MINES.

Even old abandoned mines are going to be put to some possible use according to the latest suggestion: A mine superintendent in the Joplin-Miami, Mo., district has visions of making a fortune out of mushroom raising in the abandoned mine drifts in that section. They are continually warm, just about moist enough, and in those where mules have been utilized for ore hauling there is plenty of good soil. The superintendent has rigged up an ingenious electric lighting scheme, with tinted globes, some one having told him mushrooms must have a little light, even if it is not sunshine, and he has planted his first bed and is awaiting results. If it works he estimates there is enough acreage in the abandoned mines in the district to produce mushrooms for the whole world.

Airplanes in Mine Rescue Work

Quick Transportation of Rescue Apparatus to Mine Disasters

By F. J. Bailey
Assistant to the Director, U. S. Bureau of Mines

IN the fall of 1919, the U. S. Bureau of Mines began an inquiry as to the possibility of utilizing airplanes in conjunction with its rescue work, for quickly transporting engineers and oxygen rescue-apparatus to mine disasters.

It was realized that this proposed use of airplane has serious limitations, and, if it were feasible, that the Bureau would have to rely on the coöperation of the established aviation fields of the U. S. Air Service for furnishing airplane service. Therefore, Van. H. Manning, Director of the Bureau of Mines, under date of October 28, 1919, wrote the Director of Air Service outlining the rescue and first aid organization of the Bureau, the location of headquarters of district engineers, the distribution of safety cars and stations, and other essential details, and asking whether the Air Service could coöperate with the Bureau in the event of serious mine disasters. Major-General Charles T. Menoher, Director of Air Service, responded that the Air Service would be glad to coöperate insofar as possible, and designated those Air Service stations nearest the district engineers' headquarters, which might be best able to assist.

The Bureau of Mines has ten mine rescue cars and eight mine safety stations distributed throughout the mining regions of the United States. The cars are each equipped with sets of oxygen mine-rescue breathing-apparatus and first-aid supplies. The car personnel consists of a mining engineer, surgeon, foreman, first-aid miner, clerk and cook. A foreman miner is in charge of each station and at five of the eight stations are mine safety trucks. The work of the cars and stations is twofold: (1) Assisting in rescue and recovery work at mine disasters, and (2) training miners in mine rescue and first-aid methods, and in investigations looking to prevention of mine accidents. The country is divided into nine safety districts, with nine district engineers in charge.

A preliminary survey has indicated that airplane service might be effectively utilized in the flat-flying coal-fields of Illinois and Indiana, and a coöperative agreement has been made whereby McCook Field, Dayton, Ohio, will maintain in readiness planes for assisting the Bureau of Mines safety station at Vincennes, Indiana, in its rescue work.

The Bureau of Mines district engineer at Vincennes will collect data on possible landing-fields near the mines in this district, with maps indicating these land-places, their proximity to mines, or to towns and railway stations.

In event of the Vincennes station receiving word of a serious mine disaster at a mine where a landing field is available near by, or where train or auto connection could be made with a decided saving of time, a call for planes could be sent to McCook Field. The planes could land at the Vincennes municipal landing field, where the district engineer or foreman miner of the Bureau's station would be waiting, taking on gasoline and other supplies needed from the Bureau of Mines service station, maintained there, and carry the Bureau's engineer with sets of rescue apparatus to the landing field near the scene of the disaster.

The Bureau's engineer will thus be able to assist in directing the preliminary steps in effecting an organization for recovery work. In the meantime, a fully equipped Bureau of Mines rescue car or auto truck can be rushed to the mine, and on arriving there will find an adequately directed organization already functioning, thus saving valuable time. This may result in saving lives that might otherwise be lost.

CONSIDERATIONS AS TO EFFECTIVENESS OF AIRPLANE USE.

Much remains to be done before any decisive statements can be made as to the extent and effectiveness with which airplanes can be utilized generally in mine rescue work throughout the country. The difficulties and problems involved are many, some of these are discussed in the following paragraphs:

The distance of the Air Service stations from the Safety stations, and then to the mines, is a prime consideration. The Air Service stations are on an average of 150 miles from the safety stations, but some of them are much farther. Information as to flying time compared with time of travel by railroad or auto service is needed to predict whether airplane service, or combined air and surface service could be utilized with advantage.

The greatest problem is that of suitable landing fields. First, fields must be available at the town where the safety headquarters are situated; second, fields must be established at the mines. As regards establishing landing fields near mines, careful survey for level places that could be prepared without much difficulty is necessary. In mountainous mining districts there are at many mines no level places suitable for landing. Such conditions are found in metal and coal mining districts of the Rocky Mountain States and the Pacific Coast States, and in a number of the coal fields of the Appalachian region.

The present types of airplane require a landing space about 1,800 feet in extent in both directions. The development of planes capable of ascending from, and descending to, a landing within a limited area would overcome the present lack, at many mine, of safe landing areas.

CARRYING CAPACITY AND FLYING RADIUS.

The service stations must have planes suitable for the work. Some Air Service fields are not at present equipped with types of planes suitable for carrying additional load, such as a passenger and rescue apparatus, or with planes carrying sufficient gasoline to provide a good flying radius.

Flying at night, especially in a mountainous country, would not be feasible. Neither could ships safely take the air in stormy weather. In regions of heavy snow, as in the Lake Superior District, planes could not be used in winter months, because the obliteration of land-marks by a deep blanket of snow makes it difficult for the aviator to pick his route with certainty.

An aerial map of the mining districts, showing safe landing fields, established aerial routes, and similar data is essential. The Civil Operations branch of the Air Service has made much progress on the mapping of commercial landing fields, and the development of a system of aerial routes. The Bureau of Mines engineers in their field work will be able to compile data on the surface conditions near each mine visited, and map places suitable for landing fields.

CONCLUSION.

In conclusion it should be remarked that too much should not be expected for the present in the use of airplanes in mine-rescue work. The prospects for such utilization in the mountainous districts of the West, or in hilly regions of the East, are not bright. In the mining regions of Illinois, Indiana and other middle states where the surface is comparatively level, there are excellent prospects that airplanes can frequently be used with advantage. If such use should result in the saving of lives at even one disaster, it would amply justify all the time and effort expended in this work. Moreover, as the commercial use of the airplane expands and improved types capable of landing in a small area appear, the field of application of airplanes to mine rescue work will be greatly broadened.—U. S. Bureau of Mines, Reports of Investigations.

Automobile Exhaust Gases in Vehicular Tunnels

What Per Cent of Carbon Monoxide Can Be Endured with Safety?

By A. C. Fieldner, Supervising Chemist, Pittsburgh Experiment Station, Bureau of Mines

THE rapidly increasing use of motor vehicles and trucks in the United States is creating an entirely new problem in the proper ventilation of tunnels, subways and other confined spaces through which such machines must pass. This problem has become of immediate importance because a tunnel 8,000 feet long is being designed to pass under the Hudson River between New York City and New Jersey. Another tunnel at Pittsburgh, 5,700 feet long through the South Hills, is already under construction, and a third tunnel, 6,000 feet long, between Boston and East Boston, is proposed. It is probable that other tunnels will be started in various parts of the United States in the near future.

The ventilation of such tunnels is a serious matter on account of the poisonous nature of automobile exhaust gases. It is not uncommon to read about finding a man dead in his garage. Generally this happens on a cold winter morning, after he has been running the engine with the doors and windows closed.

The poisonous constituent of automobile exhaust gas is carbon monoxide. It is the same gas which has caused the death of so many miners after mine fires and explosions. It is also found in illuminating gas, and there, likewise, has caused the death of many persons.

Carbon monoxide has no color, taste, or smell. The smoke issuing from the exhaust of an automobile is not carbon monoxide, although where there is smoke there is usually carbon monoxide present. The amount of it present in automobile exhaust gases varies under different conditions of running a machine. Probably the principal cause for variation is the adjustment of the carburetor. A rich mixture may give as high as 10 per cent carbon monoxide in the exhause gases. A very lean mixture will give an exhaust gas containing nothing, or perhaps not more than one or two per cent. All gradations between these percentages occur. For this reason, engineers who have to design the ventilation for tunnels have no accurate information on what the average percentage of carbon monoxide is likely to be.

Very few tests have ever been made on cars taken from the street and tested in the condition under which they were operated, and the only way to obtain this information is to run a great many tests on the road under exactly the same conditions as will prevail in tunnels, using cars and trucks of various sizes, so that average results may be obtained for each type of machine.

METHOD OF CONDUCTING AUTOMOBILE ROAD TESTS.

In order to obtain information as to the amount and composition of automobile exhaust gases, the Bureau of Mines has undertaken to make tests at its Pittsburgh station, on a number of passenger cars and trucks, about 100 in all. The expense of carrying out the work is being borne by the New York and New Jersey State Bridge and Tunnel Commissions, who need the information for designing the tunnels under the Hudson River. Pittsburgh is also contributing to the work by furnishing the necessary cars and trucks for making the tests, as the local need for the information is great, to insure adequate ventilation for the tunnel under the South Hills.

In making the tests an accurately graduated tube containing the gasoline to be used is attached to the carburetor. Another apparatus for collecting the gas sample is attached to the exhaust pipe by means of a rubber tube. The car is taken to the test course and run for exactly one mile at the required speed. During this period the gasoline is accurately measured and a sample of gas is collected. The gas sample is sent to the Bureau of Mines laboratories and is carefully analyzed for all constituents; and from these results the number of cubic feet of carbon monoxide given off by the car is calculated.

Tests are made on a level grade and up and down a three per cent grade, at rates of speed of 6, 10, 15 and 20 miles per hour. Tests are also made with the engine racing, idling, and accelerating, so as to reproduce conditions in a tunnel when it is crowded with cars which are starting up after a blockade in the traffic. Nothing is overlooked in obtaining information which will show the worst possible conditions that might arise in a tunnel.

EFFECT OF CARBON MONOXIDE

The carbon monoxide in exhaust gases is an active poison, for the reason that it unites with the red coloring matter of the blood and prevents it from taking up oxygen from the air. The victim really suffocates in much the same way as if his air supply were shut off. Only very small percentages of carbon monoxide are needed to render a person unconscious. One per cent in the atmosphere will produce death very quickly. I have been in 0.1% carbon monoxide for one hour, and suffered a distinct headache from this exposure.

In order properly to calculate the amount of air that is needed to sweep out exhaust gases from a tunnel, engineers must know what is the largest allowable percentage of carbon monoxide that a person may breathe for several hours without any ill effects whatsoever. This problem is also being investigated by the Bureau of Mines. The work is carried on by Dr. Yandell Henderson, of the Bureau, at the Physiological Laboratory of Yale Medical School, New Haven, Connecticut. He is determining just how many parts of carbon monoxide in 10,000 parts of air may be considered safe.

At the present time authorities differ somewhat in this respect. Practically all of them agree that 1 to 3 parts in 10,000 are perfectly safe for at least an hour. A few authorities believe that even 5 or 6 parts may be safely tolerated. The work being done by the Bureau of Mines should determine which figure shall be used. These tests are made by subjecting a large number of people, who volunteer themselves for test, to air containing these small percentages of carbon monoxide.

VALUE OF TESTS TO OWNERS AND DEALERS

The automobile exhaust gas tests when completed will also be of great value to owners of automobiles and trucks, and also to dealers, as it will furnish reliable unbiased information on the efficiency of a given machine under particular conditions. For example, the tests thus far may have shown no difference in the efficiency of different makes of cars and trucks as regards gasoline economy, but cars of the same make showed large variations, due to the fact that the owners were running the machines with improper adjustment of carburetors. Most of them were using very rich mixtures. In fact, the average of 24 cars tested showed that 20 to 30 per cent of the heat in the gasoline went out in the form of unburned gases in the exhaust. In other words, if the mixtures had been leaner, the owner would have obtained 25 per cent greater mileage from a gallon of gasoline.

Drivers naturally adjust their cars to start easily in the winter time. This means that they will use rich mixtures.

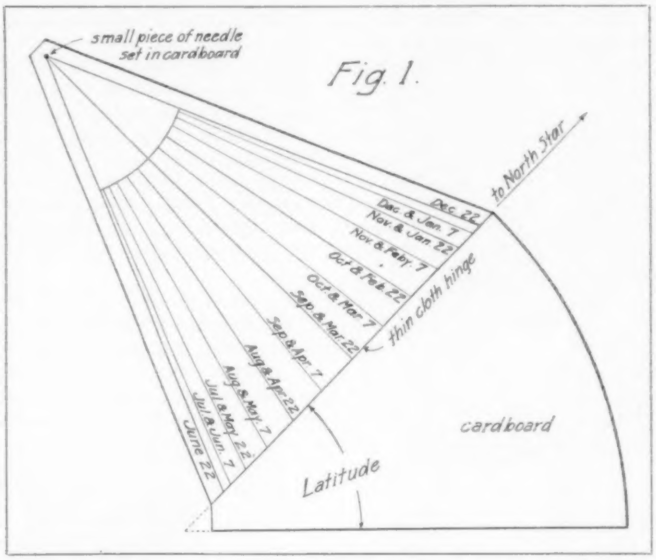
It is expected to continue the automobile and truck tests throughout the summer, in order to find out whether less carbon monoxide is produced when the machine operates in warm weather, and the Bureau of Mines is very anxious that owners of automobiles and trucks continue their coöperation in furnishing cars for test.—U. S. Bureau of Mines, Reports of Investigations.

Determining a Meridian from the Sun

A Readily-Made Pasteboard Instrument

By John D. Adams

IN surveying the public lands, the U. S. General Land Office makes use of the usual surveyors' transit equipped with a solar attachment. This device makes it readily possible to determine a meridian with an accuracy of a minute or two in arc—a result, however, that necessitates very close adjustment of the several portions of the mechanism. In its most improved form the attachment is rather formidable in appearance, and in this doubtless lies the reason why so many engineers avoid it and are unfamiliar with its principle of operation.

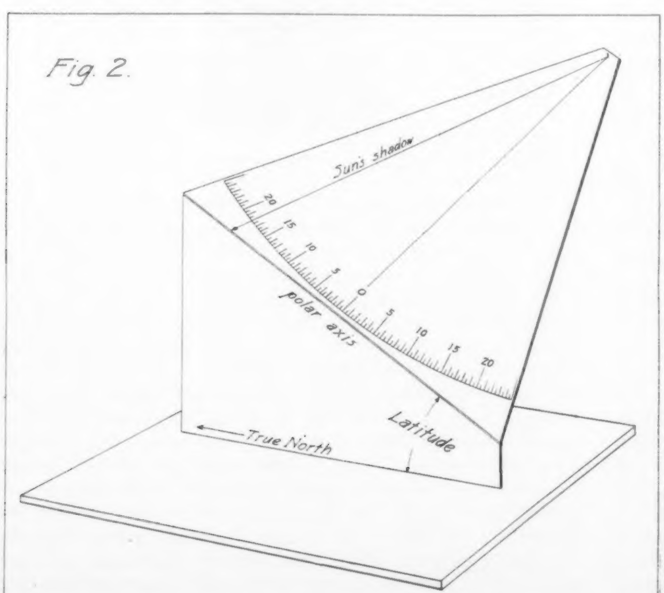


LAYOUT OF THE DEVICE FOR DETERMINING A MERIDIAN FROM THE SUN

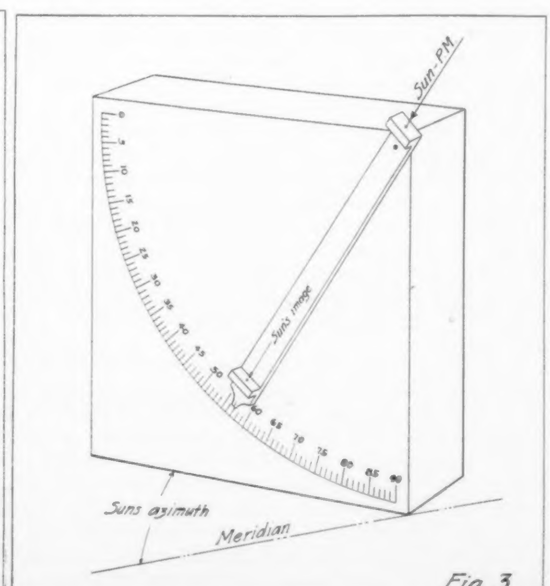
The surest and certainly the most interesting way of gaining a clear and practical understanding of some seeming obscurity is to provide, where such is possible, a working model reduced to mere essentials, the manipulation of which if it does not accomplish more than pages of written text will surely aid in elucidating them. It is accordingly the writer's purpose to present, in place of the telescope, mirror, latitude and declination arcs of the solar attachment, a simple and interesting device, consisting of two pieces of cardboard, with which an approximate meridian may be mechanically determined on precisely the same principle that lies hidden in the highly improved instruments used by the United States surveyors. By making such a device in a somewhat more durable form, a means will be provided whereby a meridian may be quickly determined within a degree—a result hardly to be expected with the magnetic needle with all the uncertainties of local attraction.

From the center point on one side of a piece of smooth, flat cardboard erect a perpendicular from four to six inches long. Using a point near the upper end of this line as a center, draw six radii on the right hand side of the perpendicular making the following angles therewith: 23°-27′; 22°-30′; 19°-53′; 15°-47′; 10°-37′; and 5°-23′. These will represent the sun's south declinations, and should be dated as indicated in Fig. 1. On the other side of the perpendicular draw six similar radii for the north declinations at the following angles: 23°-27′; 22°-41′; 20°-20′; 16°-38′; 12°-00′; 6°-27′, which are also to be date as shown.

Cut another piece of cardboard to the exact angle of the latitude of the place where the device is to be used, and then fasten the two pieces together with a thin cloth hinge. Through the central point of the radial lines tightly insert a piece of sewing needle just long enough to project about one-sixteenth of an inch on each side of the cardboard. At some convenient point where the sun's rays are available, place the lower edge of the lower piece of cardboard on a level surface,



HOW THE PASTEBOARD INSTRUMENT IS MOUNTED



SIMPLE DEVICE FOR "DIRECT SOLAR" OBSERVATIONS

holding the same as nearly vertical as possible with one hand. With the other manipulate the other piece of cardboard until the shadow of the piece of needle lengthens out as far as the hinge, when it will be evident that it is in the plane of the sun's rays. While maintaining this condition, move the whole about on the level surface until the shadow falls on the radius corresponding to the date of observation, when it will be found that the vertical piece of cardboard is in an exactly north and south position. A few trials will show that in no other position will these few simple conditions be met. To demonstrate this, simply set the latitude section in any position but on the meridian, and it will at once be found that at no possible angle of the hinge will the sun's shadow lengthen out across the proper date line.

MOUNTAIN SOLAR TRANSIT, SHOWING ENLARGED LATITUDE AND DECLINATION ARCS

If it is desired to make the experiment in the afternoon, draw radial lines on the side shown in Fig. 1; if in the morning, the other side should be used, as in Fig. 2. In common with the modern solar attachment, the best results cannot be obtained within two or three hours of noon, a fact that is not due to any defect in principle, but to the smallness of one of the angles in the involved spherical triangle.

As our years are not all of the same length the sun's declination is not always the same on identical dates, in consequence of which more accurate results may be obtained by replacing the date lines with a declination arc on either side of the center line. By consulting the current ephemeris of the sun, the exact declination may be determined and then indicated on the arc by a light pencil mark, through which the sun's shadow may then be caused to pass. By means of a metal protractor having a projecting arm, it is a comparatively simple task for a draftsman to lay out the necessary scale to at least half degrees.

It should be understood that the accuracy of the results depends to a certain extent on having the horizontal surface quite level, a condition, fortunately, that is easy to attain with a piece of board and a small level. Though not so important a condition, the latitude sector should be held vertical, but those who wish to make use of the device for practical purposes would, of course, dispense with the cardboard entirely and construct a base of substantial width that would always stand vertically. The latitude sector could be made adjustable, the cloth hinge replaced by pivots, and other improvements would doubtless suggest themselves.

It is not the purpose of this article to go into the theory of the solar observation, as those who are interested can find it duly expounded in standard works, but it is hoped, after a little experimenting with the cardboard model, that what had previously appeared a very abstruse matter, necessitating a complicated mechanism and elaborate mathematical treatment, is essentially a very simple idea.

In this connection it may be well to refer to another form of solar observation, also used by the U. S. General Land Office, called the "direct solar." The sun is observed through the main telescope of the transit, and its altitude in a vertical plane measured. Its azimuth is then calculated by means of the following formula:

$$\text{Cos Azimuth} = \frac{\text{Sin Declination}}{\text{Cos Latitude} \times \text{Cos Altitude}} - \text{Tan Latitude} \times \text{Tan Altitude}$$

For south declinations the sun's declination is considered negative. If the algebraic sign of the result is positive, the azimuth is referred to the north point; if negative, to the south point.

In this form of observation the involved spherical triangle is solved mathematically, whereas with the solar attachment the solution is effected mecanically. By means of logarithms the above formula is reduced very quickly, and in taking a set of several readings it will be noted that all but the two terms involving the altitude may be considered constant.

PRECISE TRANSIT WITH TELESCOPIC SOLAR ATTACHMENT

An interesting and simple means of experimenting with this form of observation for meridian is illustrated in Fig. 3, and although only paper and wood enter into the construction it is readily possible to determine thereby a north and south line with an error of less than thirty minutes. A well seasoned block about five inches square and an inch and a half thick should be procured from the mill, where facilities are always available for securing a high degree of accuracy in sawing. On one surface only a paper protractor, reading to thirty minutes, is to be attached by means of glue—the glue being applied to several small spots rather than to the entire surface to prevent warping. In placing the protractor, set the block on a perfectly flat surface, and line up the 90° mark with a steel square, which may also be used to determine whether the surface of the protratcor stands at right angles with the horizontal surface. This condition is important, and any slight adjustment that may be necessary may be made by pasting on a narrow strip of paper along the proper edge

of the base. Prepare a small radial arm of the form illustrated, and in the upper projection drill a hole about the size of a pin, so that the sun's rays may pass through and illuminate a small spot on the lower projection. This arm is attached to the block by means of a pin or small nail near the upper end put in at the exact center of the protractor. Set the arm at 90°, and with the steel square resting on the same horizontal surface as the block, make a small dot on the lower projection of the arm to indicate where the sun's image should fall.

To determine a meridian, carefully level up any convenient flat surface, on which the block should be moved about until the surface of the protractor is in the plane of the sun. Adjust the angle of the arm until the image falls on the small indicating dot, then record the sun's direction by drawing a line with a sharp pencil on the horizontal surface using the lower edge of the block as a ruler, after which read the altitude. The above formula will then give the relation of the sun to the meridian, which may be laid off with a protractor set on the line prveiously drawn.

By consulting an ephemeris it will be seen that for practical purposes the exact time is not a matter of great importance. To avoid the necessity of interpolating with the eye in reading the altitude, one may follow the sun for a minute or two until the reading is an exact division on the arc, when the mark may then be made on the horizontal surface. This may be repeated several times in a few minutes, and the mean of all the results taken.

A very convenient ephemeris of the sun and Polaris may be had from the Superintendent of Documents, Government Printing Office, Washington, for five cents.

AN IMPROVED TOWING SPAR WHICH CAN BE USED AS A NAVIGATIONAL INSTRUMENT.

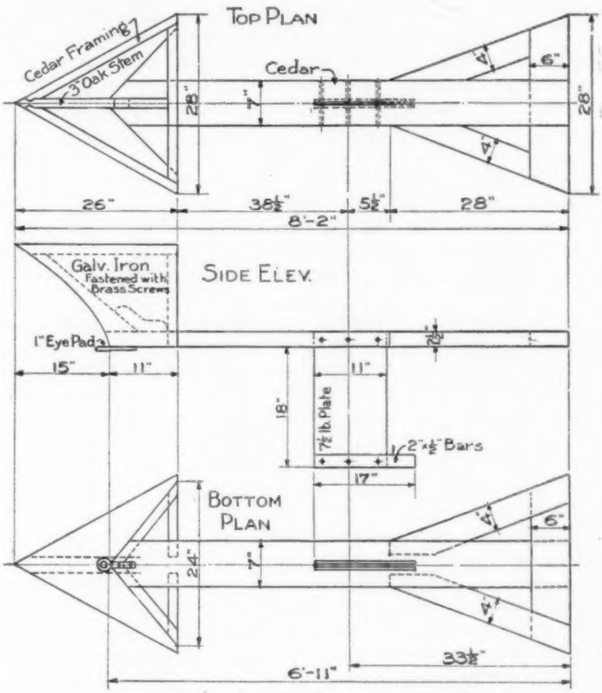
By LIEUT. COMMANDER S. F. HEIM, U. S. Navy.

IN these days of radio compasses and gyro controlled artificial horions, it might be considered rather late to offer a scheme for taking sights by bringing the heavenly body down to a spar towed by the ship. The writer has read in the U. S. Naval Institute Proceedings of sights being taken on the waterline of another ship, on a boat sent out by the ship and even on a chip log astern of the ship, but never on a towing spar which would seem to be the logical method because it can be let out from the ship without stopping or altering speed and its distance from the ship can be controlled accurately by marks on the tow line.

The scheme seemed so simple and plausible that the writer wondered why it had not been done before and he inquired of experienced officers and searched the files of the Naval Institute but failed to find where it had ever been tried. To test his theory he went out in the bay off Greenbury Point on a submarine chaser and steamer both day and night and took sights, using an ordinary towing spar with only 350 feet of line. A small waterproof storage battery light was attached to the spar at night. The results of these trials were accurate far beyond expectations. These results in altitude difference by Marcq Saint-Hilaire method were accurate within 1 minute of arc.

Of course it is realized that conditions here were ideal, with no wave movement of either the spar or the ship; but it is proposed to eliminate these errors as far as practicable at sea by use of the improved towing spar which will remain afloat with 500 or 600 yards of line out from the ship. The longer the length of line the more accurate will be the results. The maximum possible error due to rising and falling of spar in sea will be the angle with tangent equal to maximum rise divided by length of tow line. Thus with a 3-foot rise and fall of spar with 600 yards of line the maximum error would be 5 minutes in altitude.

The three views of the towing spar are self-explanatory and a description is unnecessary. This spar was developed and used by the commanding officer of the "U. S. S. Charleston" while engaged in convoy duty during the war. The old navy towing spars and special sheet metal tank spars supplied to ships were useless for this work because they would tow under at the distances at which they were desired to be used. The towing under was caused by two things: their shape and the towing line. The improved spar shown in sketch was towed by a small wire rope of about the diameter of a lead pencil. This wire line was wound on a small reel secured just forward of the quarterdeck winch. The spar was hauled in by means of the deck winch. It was found that manila line was unsatisfactory for towing spar work because the waterlogging and friction tend to pull the spar under. It will be noted that a strong keel or centerboard is attached to the spar. This is an important feature which causes it to tow during turns and prevents capsizing.



TOWING SPAR USED ON THE U. S. S. "CHARLESTON"

By having at hand a table of "dips" to use for different speeds and lengths of tow line, the operation of taking a sight would be comparatively simple. He could take the bearing of the heavenly body to be observed and then head the ship directly away from the body and with spar out take a series of sights. The average of the series should be taken to counteract the errors due to wave heights of the spar. By practice in fair weather when the "dip corrections" are computed he could determine the limits of accuracy and how much confidence to place in it when occasion for its use arrives. We have all experienced the occasion when a sight was highly desirable or even necessary with the sun out or stars shining but no horizon visible.—Copyrighted by the U. S. Naval Institute. Reprinted by permission, from the *Proceedings* of the Institute, March, 1920.

CONCRETE PONTOONS FOR SHIP SALVAGE.

A SET of reinforced concrete floats have been built by Messrs. Christiani and Nielsen says *Le Génie Civil* (Feb. 21, 1920) for the salvage of ships. The floats are cylindrical and measure 21 meters long and 3.60 meters in diameter. Each float has a bearing capacity of 100 tons and is designed to lift 200 tons. It can withstand an external pressure 2 kg. per cm^2 and in exceptional cases 4 kg. per cm^2 so that it may be used at depths of 40 meters.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

SELENIUM AND TELLURIUM.

TWO "RARE ELEMENTS" WITH POSSIBILITIES.

By Victor Lenher,

Professor of Chemistry in University of Wisconsin, and Member of the National Research Council's Committee, on the "Uses of Selenium and Tellurium."

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

THE two "rare elements," selenium and tellurium, which are in many respects similar to sulphur, are not so rare as in generally supposed. Indeed the term "rare element" is in general a rather vague and indefinite expression. For example, titanium is commonly regarded as a rare element, although F. W. Clarke has shown it to be more plentiful than carbon, sulphur and phosphorus combined. Titanium is, therefore, very plentiful, but the number of its chemical compounds is very limited.

A recent estimate of the amount of selenium and tellurium that can be produced at present in the United States, without making any material additions to the present plants, has shown that this country can furnish annually more than 300,000 pounds of selenium and about 125,000 pounds of tellurium. The elements are marketed commonly in elementary form although some of the refineries have produced small quantities of derivatives, such as sodium selenite and tellurium dioxide.

The general chemical characteristics of these two elements closely follow those of sulphur, indeed the types of selenium and tellurium compounds are in general those of sulphur, but due to their higher atomic weights they are more metallic. Tellurium in elementary form looks much like antimony. It is white, strongly crystalline, so strongly crystalline that it is quite brittle and can be easily powdered. Toward the acids it is as refractory as antimony. Toward alkaline solutions it is strongly resistant while in water or in moist air, it does not rust or corrode appreciably. It is known that antimony can be electroplated and gives a durable plating. It would be interesting to study tellurium in this direction. A systematic study of the available electrolytes that can hold tellurium in solution could be carried out advantageously. Antimony has been successfully used for many years in antifriction alloys and is an essential constituent of stereotype metal. No recorded study is known of an attempt to utilize tellurium in these alloys. The whole field of the metallic alloys of tellurium needs to be studied carefully, and, unquestionably, an element whose general characteristics are so close to antimony will almost certainly be found to be a useful metal instead of as at present having no practical applications.

Another metallurgical line which has not been studied in any detail is the action of these two elements in the iron and steel industry. The effects of sulphur and phosphorus on iron and steel have been very carefully studied. The objectionable phosphorus has been most scrupulously removed by the basic open-hearth process as a result of years of study and observation, yet today we are actually adding iron phosphide to open-hearth steel, which is to be used for certain purposes, to bring up its phosphorous content. It is interesting to contemplate what careful experimentation would develop on the influence of selenium and tellurium on the various grades of steel.

Selenium in the so-called metallic form has long been characterized by its unique action toward light. Its conductivity of the current varies so greatly when brought from the dark into the light that this peculiar property of its conductivity, varying as it does, directly proportional to the intensity of the light, has caused the development of the selenium cell. This cell, or, in reality, a resistance apparatus, has found numerous uses at various times, such as automatically turning off city gas lights at daylight. It has been used in lighting and extinguishing the lights in light buoys, in army signalling of various kinds based on the heliograph principle, as a control in chemical processes such as the contact sulphuric acid manufacture, and in the wireless telephone.

It has been known for a long time that selenium gives to glass a red color. This principle during the wartime was made use of in the decolorization of glass owing to the shortage of manganese which had been hitherto used largely for this purpose. Selenium is introduced into the glass either in the elementary form or as a salt of selenium. The rose color which selenium imparts to the glass is not exactly the complement of the green of the ferrousi ron hence it is common practice to add a small amount of cobalt oxide along with the selenium. Since both selenium and its compounds are very readily volatile at such temperatures as are used in glass making, a large amount of the selenium decolorizer is volatilized. The loss of selenium is therefore high, and as a consequence selenium can only be used to decolorize glass when the glass manufacturers are willing to pay the higher cost price. During the war when the supply of manganese was limited selenium was used extensively in glass decolorizing, but as soon as shipping was resumed and manganese again became available, the use of selenium in the glass business fell to almost nothing.

There are a number of possible uses that suggest themselves for these elements, none of which has received the attention that it deserves. Lithophone, the intimate mixture of barium sulphate and zinc sulphide made by bringing together barium sulphide and zinc sulphate, is full of suggestions. Various colored lithophones can be produced by using an antimony sulphate liquor with barium sulphide when the white barium sulphate produced is colored by the orange sulphide of antimony. Similarly cadmium or arsenic liquors give a corresponding yellow lithophone. The substitution of selenium and tellurium in lithophone is very suggestive inasmuch as it should be possible to replace the sulphur of either the sulphate or that of the sulphide by either of these elements. The selenate and tellurnate of barium are white and insoluble like the sulphate, while the selenides and tellurides like many of the metallic sulphides are variously colored.

The uses of the various compounds of selenium in medicine have received some attention, but the derivatives have had almost no systematic study. Professor W. J. Gies, of Columbia University, in a very careful study has shown that tellurium compounds have a physiological action quite similar to that of arsenic, but that the toxicity is much less than that of arsenic. The selenides and tellurides as well as the oxidized salts have been experimented with in cancer, tumors, and syphilis, but their efficacy is more or less questionable. These few compounds, which are of the simplest chemical character,

are almost the only ones of which any experimental results are recorded. When one considers the vast field of important and valuable sulphur-containing organic compounds ranging from saccharin to sulphur and in the arsenicals from Fowler's solution to salvarsan, it would seem that there exists an almost virgin field for research by the physiological chemist. When one thinks of the physiological action of the derivatives of tellurium as medicinals, the offensive garlic odor of the "tellurium breath" is brought to mind. This will unquestionably act as a deterrent in the minds of some, but should certain physiological actions be found, they might be so valuable as to overcome the objections due to the characteristic methyl telluride odor.

In the vulcanization of rubber a few experiments are recorded which seem to indicate the similarity of the action of selenium to that of sulphur. Much more remains to be done especially along the lines of the use of the chlorides or bromides of these elements as accelerators. Tellurium and its derivatives have received practically no attention in the rubber industry. Possibly from the nature of the organic materials present, the objectionable methyl telluride again would militate against its use.

A relatively small amount of research has been conducted with selenium in the dye industry while almost nothing has been done along these lines with tellurium. One of the first lines that would naturally occur to one would be the substitution of selenium for sulphur in the so-called sulphur colors. These are among our cheapest colors. There are at present two serious obstacles in the replacement of sulphur by selenium in the sulphur colors. The first is the relative cost of selenium to that of sulphur. The second is the nature of the bath which in the present development of the sulphur color process would make the cost prohibitive. There is, however, the possibility that a brilliant and fast color of considerable intensity could be found which could be manufactured profitably. The field of synthetic dye-stuffs does, however, possess great opportunities for experiment and is almost undeveloped.

The utilization of the less common elements has always been a problem which has interested chemists. Not many years ago elementary silicon was sold at a high price per gram and even then it was almost a curiosity to be found wholly in museums, yet in combined form it comprises one-fourth of the crust of the earth. Today silicon in elementary form is produced in large quantities at a few dollars per ton and is used on a large scale in deoxidizing non-ferrous alloys. Similarly a few years ago, tungsten was known only as a gray metallic powder with no other uses than that of the formation of the self-hardening steels. Today the use of malleable tungsten wire in the lamp bulb and of the sheet metal in the spark coil to replace the more expensive platinum, makes metallic tungsten a very important commercial product. Along the same line molybdenum, tantalum, and the oxide of zirconium are substances which until recently were only museum specimens but today are very useful products. Only a few years before the war, large money prizes were offered in Europe for methods of utilization of bromine and of boron. We well know how valuable an element bromine was during the war and of its large consumption since the war, particularly in organic synthesis.

All of the elements which nature has furnished to us must find their place as a useful necessity to man. It is indeed incomprehensible to think that in the entire chemistry or physics of one or more elements there cannot be at least a single compound or property that can be utilized by mankind.

Except for the wartime use of selenium in the glass industry, the present uses for selenium and tellurium are very limited. A few hundred pounds of each would supply all demands. The large amounts of these elements which are available today and for which there is no practical use, have caused the National Research Council to create a committee on the Uses of Selenium and Tellurium. This committee, consisting of A. E. Hall, Chairman, with H. G. Greenwood, Victor Lenher, O. C. Ralston, E. W. Rouse, S. Skowronski and A. W. Smith, has been working in close contact with the producers of selenium and tellurium in the United States, and it has been possible to make arrangements whereby large quantities of these elements can be secured at a very low figure for experimental purposes. The Raritan Copper Works, Perth Amboy, N. J., the U. S. Metals Refining Company of Chrome, N. J., the American Smelting and Refining Company, Omaha, Nebr., and the Baltimore Copper Smelting and Rolling Company, Baltimore, Md., which includes all of the producers of these elements in this country, will furnish workable quantities of these elements for research purposes at cost price.

Mr. E. W. Rouse, of the Baltimore Copper Smelting and Rolling Company, will ship at any time reasonable quantities of selenium to investigators gratis, upon the recommendation of the Committee of the National Research Council on Uses of Selenium and Tellurium, and Mr. Arthur E. Hall of the Omaha Plant of the American Smelting and Refining Company, will forward reasonable quantities of tellurium, gratis, under the same circumstances.

THE SEARCH FOR CEREALS.

By H. E. Howe, Vice-Chairman of the National Research Council's Division of Research Extension.

Notwithstanding the still unsettled question as to whether heredity or environment exercises the greatest influence upon an individual, it seems certain that both play a very vital rôle in plant life, particularly in the more useful plants, such as wheat, which we have had occasion to study somewhat intensively. Unfortunately, under the circumstances which produce the survival of the fittest, we can hardly secure the varieties necessary to guarantee maximum production in the various wheat areas of so large a country as the United States. Our occasional severe winters lead to the abandonment of large areas, and under these severe conditions the entire acreage in a particular locality is very apt to be wiped out, so that we have no survival which will produce seed to withstand other unusually hard winters. Statistics tell us that during the past five years a total of thirty million acres of winter wheat have been abandoned in this country, which, at the average yield of fifteen bushels, means a loss of four hundred million bushels of wheat, with a corresponding monetary loss—and, more important, a loss of food to the world.

It was to improve conditions of this sort, as well as to introduce new cereals from foreign countries, that some time ago Dr. M. A. Carleton, then of the Bureau of Plant Industry of the U. S. Department of Agriculture, began a systematic collection of cereals from foreign countries for the purpose of introducing new strains and varieties quite different from the species to be found ordinarily in North America. To what extent this work was successful may be indicated by the following:

Wheats used in the production of macaroni and the like must be unusually high in gluten. Previous to 1902, wheat satisfactory for this use was not produced in important quantity in the United States. Some years before that, a new form, now called durum wheat, was obtained from a semi-arid district in East Russia, and introduced in similar districts in our country, where other kinds of wheat do not succeed. Regular grades of this wheat were established at the different boards of trade following the harvesting of the first crop of any importance, which was, as indicated, in 1902. By 1908, our annual exports of this variety had reached twenty-seven million bushels, all of which were sent to Europe, where there is a constant demand for wheat possessing the characteristics of the durum variety.

In April, 1913, No. 1 durum wheat sold at a premium of 8½c a bushel at Duluth and 6¼c at Minneapolis over our No. 1 northern wheat. At the present time, the average crop of this variety is approximately fifty million bushels a year, and in the last two years its popularity has increased. Our Ca-

nadian neighbors have also adopted the variety. The original seed obtained in Russia was less than three hundred bushels. It will be seen at once that the result of this piece of research can be measured in millions of dollars annually, this wealth having been added to that of our farmers, grain dealers, millers, macaroni makers, and the public at large.

Another valuable variety introduced through the efforts of Dr. Carleton is the Kharkov hard winter wheat. The yield of winter wheat is much heavier than that of spring wheat in the same locality, but the winters in the great plains north of Kansas, and indeed in some part of Kansas, are too severe for any American variety. About twenty-five years ago the Russian Mennonites introduced Turkey wheat into Kansas, bringing it with them from South Russia, and later Dr. Carleton imported a large quantity of seed wheat from North Taurida, Russia, which helped the Kansas situation. In 1900, however, the Kharkov wheat, still hardier than earlier varieties, was secured from South-Central Russia, in the Starobesk district of Kharkov Province. The extensive use of this variety has resulted in the extension of the winter wheat area into Montana and portions of Minnesota and the Dakotas. Simultaneously, the growing of all hard winter wheats was encouraged because of their hardiness and their rust resistance. Of our present yearly production of from 200 to 400 million bushels of hard winter wheat, there is an average of one hundred and fifty million bushels of Kharkov variety, and the introduction of this strain has again been a benefit to all who produce, handle, or use the grain. Hard winter wheats are considered among the best in the world for milling, and are chiefly grown in that area which uses Galveston as its export outlet. This wheat also supplies the large Kansas mills, and is grown from Oklahoma to Nebraska, eastern Colorado to Iowa and the southern portions of Minnesota, South Dakota and Montana.

Simultaneously with this notable work, new varieties of oats, millet, and rye have also been brought to us. Swedish select oats have been introduced from northern Russia, and this has practically guaranteed the oat industry in some of our northern states. This variety has added more than two million dollars a year to the value of the Wisconsin crop alone. It was developed in Sweden, hence its name, and was introduced in the United States after years of acclimation in Russia and Finland. The early variety of oat, known as sixty-day oats, which really matures in ninety and not sixty days, has been invaluable to South Dakota, and in general to the north-central states east of the Rocky Mountains. It was brought to us from Poltava Province, Russia, and is perhaps the widest known variety of oats in the United States.

The *proso* or Russian millet was introduced from East Russia, and has been found well adapted to Montana and Dakota conditions, yielding much better crops in dry seasons than do other varieties. This millet is used as a breakfast food in Russia, but in this country it is fed to hogs, sheep, and chickens. It has been an important stock food in the drier districts of the northwest. The Kursk millet comes from a Russian province bearing the same name, and the kernels are considerably larger than those of the usual millet. Unlike the common millet, Kursk millet can be fed to stock with little or no bad effect upon the alimentary tract.

The use of rye in food is probably a new thought to many who are otherwise familiar with this grain. Two new varieties of rye successfully established in this country have come, one from Italy, which is remaking the rye industry in the southern states, and the other from Germany, which, as we might expect, has prospered in Wisconsin.

From the above, it would seem that the search for cereals had indeed been well prosecuted. But there is still a great deal to be done, and at the present time there is need for thorough-going research on wheats which will include not only the determining of their present status in the United States, but which will consider many of the other varieties throughout the world for the purpose of still further improving the crop here. The National Research Council is particularly interested in this undertaking, and at the present time is considering the means for continuing the search for cereals. We still need hardier winter wheats for our northern great plains and our northern central states. There are parts of the world where grain is still harvested with the cradle, and frequently the crop thoroughly ripens before the harvester reaches all parts of the field. The result is that, through many centuries, early non-shattering wheats have been developed, and these we urgently need for California and the northern Pacific coast states. Improved varieties of early spring wheats would be of great economic value for Minnesota, North Dakota, and Montana, and early maturing winter wheats should be sought for our eastern and southeastern states. California and Arizona are interested in early wheats, while our great plains and Pacific coast must have more drought-resistant wheats. Still another addition would be rust-resistant wheats for all these various areas.

In plans now being developed it is contemplated that when support has been guaranteed for this work, which is estimated to require ten years' time, visits will be made to European Russia and Siberia, Turkestan, North Africa, India, Australia, Abyssinia, Italy, Arabia, Persia, Roumania, the Balkan States, China and Japan, going out among the farmers, and gradually finding and securing samples of wheats with the desired characteristics. These samples would then be sent to the United States, where wheat nurseries, established and conducted in coöperation with certain agricultural experiment stations, would gradually raise seed from the new varieties for larger and larger experimental plots. Ultimately there would be sufficient seed to introduce on a commercial scale, and with successful variety there would be no question that its use would rapidly spread.

This, then, is a project which directly affects a large number of our people, and which can be carried on in coöperation with many agencies. From past performances, it is safe to predict that such work, if properly supported and carried through to conclusion, will be sure to yield unusual returns and be a notable instance of the type of constructive work which science can perform.

ETHYL CHLORIDE.

Albert Henning discusses the technical application of ethyl chloride in the Journal of the Society of Chemical Industry, transactions, 1920, Volume No. 39, pointing out that commercial ethyl chloride is not poisonous and is not more inflammable than benzine or methylated spirit. The material is useful in the production of dyestuffs and pharmaceuticals, as a local or general anaesthetic, for solvent purposes, and as a medium in refrigeration. In its use there is no need for high pressure apparatus since it liquefies at 30° Centigrade at a pressure of 12 pounds. Ethyl chloride is the cheapest ethylating agent and is a particularly good solvent for simple organic compounds, fats, and oils, for which it may be used in extraction. When more complex compounds, such as those containing several hydroxyl groups, are concerned, solvent action is very slight, if indeed such compounds are dissolved at all.

Ethyl chloride is the best refrigerant for use in domestic refrigerating machines, the use of which is extending. Its advantage is that it may be used at a low pressure, which need not exceed 15 pounds per square inch. When a spray of ethyl chloride falls upon a small object its temperature may be brought as low as 30° below zero Centigrade. Its use as a refrigerant is also recommended for larger installations and in most instances the circulation of cooled brine may be dispensed with, circulating the ethyl chloride instead.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

FISH SCALING IN ENAMELS FOR SHEET STEEL.

THE jumping off of small particles of enamel which results in the defect known in shop practice as "fish scaling" is probably the most serious defect to which enamels for sheet steel are subjected. It occurs intermittently in practically all the plants manufacturing this class of material in this country and entails losses running into millions of dollars to the manufacturers. At the request of the Metalware Manufacturers Association of America, the Enameled Metal Division of the American Ceramic Society, and a large number of individual manufacturers, the Bureau is carrying on a comprehensive research in an endeavor to discover the cause or causes of this defect and the methods of controlling and eliminating it. This investigation was begun in July, 1919, and has been conducted energetically ever since.

Up to the present time, the Bureau has made ninety melts of enamel comprised of 21 different compositions. These have been subjected to various treatments in firing and melting and have been applied in various ways to several kinds of steel. In all, over 4,000 sample enameled plates have been made up to date. This work has demonstrated that one of the most important factors in the production of fish scaling is too severe heat treatment in the firing of the enamel. Excess heat treatment may consist of firing the enamel at too high a temperature or of holding the enamel in the furnace for too long a time at a given temperature. Other important factors are the composition of the enamel, the physical and chemical characteristics of the underlying metal, the method of melting the chemical mixtures used in making the enamels and the shape and weight of the metal pieces that are enameled. These various factors have been investigated to a certain extent in this work and will be studied more thoroughly as the investigation progresses.

The data obtained in this investigation up to the present time have enabled the Bureau to be of very material assistance to several manufacturers in eliminating this trouble. It seems very probable that the completion of the investigation as now planned will definitely eliminate fish scaling, and likewise settle the interesting question of what is the physical basis of the phenomenon.

RELATION OF COMPOSITION OF ENAMEL TO SOLUBILITY IN ACIDS.

FOR several months the Bureau has had in progress an investigation of the relation of composition of enamel to solubility in strong mineral acids. The need for this investigation was clearly demonstrated during the war by the difficulty manufacturers of acid-resisting enameled wares experienced in meeting the requirements of chemical manufacturing plants. The manufacturers of enameled kitchen wares are also interested in this problem.

Up to the present time 33 enamel compositions have been melted and tested. While the problem is a large one and the investigational work will necessarily be continued for some time, results so far obtained indicate that some of the commonly accepted conceptions of the relation between composition and acid resistance of enamels are erroneous. The chief of these misconceptions seems to be that oxides which are similar in nature chemically will have similar effects when incorporated in enamel compositions. That this is not always true is shown by the fact that calcium oxide tends to produce enamels with very low resistance to attack of acids while barium oxide produces quite resistant enamels. In connection with the gathering of data on the chief object of this investigation, information is being secured in regard to relations of composition to their fusibility and to the tendency to chip or to craze, or crack. It is expected that as a result of this investigation the Bureau will be able to advise manufacturers of acid-resisting wares as to the methods and compositions to be used in producing wares of this class superior to any now being made, and also that it will enable the Bureau to be of material assistance to manufacturers of enameled ware for culinary purposes. As a matter of interest, it may be stated that as a part of this investigation an enamel has been produced which appears to duplicate in composition and working properties the best grades of French acid-resisting enamel.

SUBSTITUTES FOR ANTIMONY OXIDE IN GRAY COAT ENAMELS.

IN certain quarters there is objection to the more or less common practice of using a small amount of antimony oxide in one coat enamels on utensils intended for culinary purposes. This objection is based on the rather hypothetical assumption that such enamels may be slightly poisonous. Although the Bureau believes that this is probably not the case, at the request of several manufacturers of this type of ware, it has undertaken the investigation of possible substitutes for antimony oxides for making such enamels.

NEW INSTRUMENT FOR DETERMINING COEFFICIENTS OF REFLECTION.

IN the design of lighting installations and in the case of many other applications of illuminating devices, a knowledge of the value of the coefficients of reflection of walls, ceilings, or other objects may be of material assistance. The illuminating engineer, with the aid of tables and instructions issued by one of the lamp manufacturers in this country, can predict with a fair degree of certainty the illumination which will be produced by any given type of lighting installation if he knows the shape of the room and the light reflecting characteristics of the walls and ceilings.

At the present time there is no instrument available outside the laboratory which will enable the engineer to measure the coefficient of reflection of surfaces. Even when the measurements are made in the laboratory, the process is very difficult and tedious, and subject to rather large uncertainties. Several methods have been used, but most of them have given incorrect results because of an error in the value assigned to the standard surface used.

In order to remove the uncertainty in the value assigned to the standard surface and to develop an instrument which could be applied to the measurement of surfaces in place, a new instrument has been developed after extensive experiments, and a much better standardization of a reproducible surface has been made. This instrument is light and portable, and can be used with any one of a number of types of portable photometers, giving results which are reliable.

The instrument which has been developed is called a reflectometer. Aside from the photometer, which measures the light intensities, it consists of a small metal sphere from which a segment has been removed, leaving about nine-tenths of its original surface. It is painted inside with a diffusing white paint, and a beam of light is projected through a small hole in the wall onto the surface which is to be tested. The test surfaces may be compared with a standard surface or with a flat surface painted with the same paint as the sphere. It is believed that this reflectometer will fill a very real need.

GENERATING SETS FOR RADIO LABORATORY USE.

THE researches and tests in progress in the radio laboratory require the use of steady sources of alternating current of frequencies from 200 to 10,000,000 cycles per second. Several generating sets have been designed and constructed in which electron tubes and associated circuits are used to produce alternating current of the required frequency from a direct current power supply.

One of these generating sets, having a wave length range of 30 to 50,000 meters (frequency range of 10,000,000 to 6,000 cycles) has been built up with a convenient control panel for use in standardizing wavemeters and other radio apparatus.

Another generating circuit, for use in the study of insulating materials, is designed with special inductance coils and a special condenser with a scale which gives the power loss in the sample of insulating material directly, without any calculation. This generating set is supplied with power from a 600-volt storage battery of small capacity which is arranged in especially convenient form for charging, refilling, and the special care which small storage cells require.

Two low-power generating sets have been designed for portable use and are especially compact. One of these generates current at a wave length of 30 to 2,000 meters. It has six sets of inductance coils, and a variable air condenser in parallel with which a fixed mica condenser can be connected. The other set generates current of 2,000 to 8,000 meters, using three sets of inductance coils and a single variable air condenser.

An electron tube is also employed in a set for generating audio-frequency currents from 200 to 6,000 cycles which is used for alternating-current measurements, studies of telephone receivers, and other work at telephonic frequencies.

A special generating set for producing small measured voltages at radio frequencies of 200 to 4,000 meters wave length is used for measuring amplifiers and detectors. It is so arranged that the instruments which are being measured are completely shielded from both electrostatic and magnetic fields from the generating circuit, the coils of which are wound in a special way, the entire circuit being enclosed within a copper shield.

THE CATHODE-RAY OSCILLOGRAPH IN RADIO RESEARCH.

RADIO communication utilizes electric currents which alternate so rapidly that no mechanical system can follow the alternations. Consequently, the currents used in radio cannot be studied by means of the ordinary kinds of oscillographs used in other electrical work. It is very desirable to have an instrument which will follow the current in all its alternations and fluctuations, so that the wave form can be accurately traced out. This makes it possible to determine how radio apparatus will act when these currents are used, thus making improvements in design possible.

This is accomplished by the cathode-ray oscillograph, in which a beam of cathode rays is deflected in a vacuum by the action of the electric currents. This beam illuminates a fluorescent screen, and the motion of the light over the screen shows how the current is varying.

Most investigators are familiar in a general way with the principles of operation and the utility in electrical research of the cathode-ray, or Braun, tube. However, there has been very little development and constructional work done on these tubes in this country, chiefly for the reason that, except during the period of the war, cathode-ray tubes could be imported from Germany more cheaply than they could be made here. The price of a cold-cathode tube at present is about 60 marks, in Germany, according to recent quotations. Hence, it is not surprising that rather meager information has been published in America concerning the general principles of design of such tubes.

The results of a study of the design of cathode-ray tubes were given by a member of the Bureau's staff, at a recent meeting of the Institute of Radio Engineers. The device can now be designed and constructed with a considerable degree of certainty to suit a variety of different operating requirements. It is a valuable aid to the standardization of wave meters, and to the determination of wave form produced by spark and other types of radio generators. Its most conspicuous usefulness is in the study of the characteristics and behavior of electron tubes. In studying the performance of electron tubes as detectors and generators of current for radio purposes and their functioning in radio telephony, the cathode-ray oscillograph is a most powerful aid. As an implement of research, permitting visual observation of phenomena previously unseen and furnishing data for new ideas and new theories, the cathode-ray oscillograph performs a service that can be achieved by no other device.

The results of the Bureau's work on the design of these tubes will be available later as a Scientific Paper.

APPLICATION OF ROTARY DISPERSION METHODS TO COLORIMETRY, PHOTOMETRY, AND PYROMETRY.

FOR about 8 years studies in the application of rotatory dispersion methods to colorimetry and related subjects have been under way at the Bureau. The method proves to be of fundamental importance and in order that it may be more generally understood and put to practical use, a series of papers relating to it are being prepared for publication. A general paper outlining the subject and giving a resume of work already accomplished was presented to the Optical Society of America, and will be published in its journal.

STANDARDIZATION OF NOMENCLATURE OF CHROMATICS AND COLORIMETRY.

A COMPREHENSIVE, preliminary draft of a report on nomenclature and standards of colorimetry has been prepared and submitted to the Optical Society of America. This draft comprises about 50 typewritten pages and 6 tables, and has a table of contents as follows:

Introduction: Nomenclature, including General Terminology; Fundamental Psychologic Terms; Outline of the Methods of Practical Colorimetry; Classification of the Methods of Measurement Contributory to Colorimetry; Terms Relating to Transmission; the Physical Terms of Homo-hetero-analysis and Their Correlation with the Attributes of Color; Standards, including Standards of Spectral Energy Distribution; Transmission Standards, and Reflection Standards.

Bibliography: Usage of Terms Relating to the Attributes of Color and Their Correlatives in Stimulus; Usage of the word "Light."

TREATISE ON PYROMETRIC PRACTICE.

THE Bureau has completed the manuscript of a comprehensive treatise on modern pyrometry under the title "Pyrometric Practice." The object of this treatise is to provide investigators, manufacturers, and others who may be concerned with the measurement of high temperatures with complete information as to the present state of the art of pyrometry, the instruments and methods used, the precautions that must be observed to obtain correct results, and to illustrate some of the industrial applications of pyromery. The scope of the paper is indicated from the following subheads: Temperature scale; high temperature therometry; thermal electrical pyrometry; optical pyrometry; radiation pyrometry; resistance thermometry; recording pyrometry; high temperature control; melting point methods at high temperatures; standardization of pyrometers and industrial applications of pyrometry. This paper will be ready in 6 to 9 months. The completed volume will consist of 300 pages and will contain a large number of illustrations. The number of copies available for free distribution will probably be small, but provision will be made by which it can be obtained at cost from the Superintendent of Documents.

SOME NEW EXPERIMENTS WITH THE LEUCOSCOPE AND ITS APPLICATION TO PYROMETRY.

THE leucoscope is an instrument developed and used by Helmholtz and his pupils between 1878 and 1888, primarily for the study of vision. Since that time practically no further work has been done with it. Recent experiments at the Bureau have shown the applicability of the instrument to pyrometry and new laws of the instrument have been discovered relating its readings to temperature and spectral energy distribution in a light source or furnace. These data were communicated to the Optical Society of America and will be published in the journal of that society.

USE OF "OVER-SANDED" MIXES OF CONCRETE.

IN commercial work it has been found that concrete foremen will decrease the ratio of sand to gravel so as to produce a better working concrete, namely, one with more fine material in it; and preliminary work has been started in the laboratory to determine the effect of "over-sanding" the time-honored 1:2:4 and 1:3:6 mixes in which the ratio of fine to coarse aggregate is 1 to 2. Very often with the very best of material these standard mixes, if actually used, will produce harsh, segregating, unworkable mixes. This is particularly true when crushed slag or crushed stone are used as coarse aggregate. One of the tests which has been carried out was in conjunction with a practical problem. A crushed limestone was submitted for test in 1:2:4 concrete with river sand as the fine aggregate. This mix was made but was found to be harsh and segregating. A 1:3:3 mix of the same materials was found to be much more workable when made so as to have the same consistency. Strengths were found to be higher for the over-sanded mix at an age of 28 days, and it was also found that contrary to the general belief less cement was used in the over-sanded mix. The following table shows the results numerically:

Mix	% Water	Cement Lb. per cu. yd.	Compressive strength Lb. per sq. in. 28 days old
1:2:4	8.33	508	768
1:3:3	8.86	487	988

The consistency of the mix was wet and was the same for both mixes.

Further tests are under way and the following mixes in two consistencies have been made up: 1:2:4, 1:2-½:3-½, 1:3:3 and 1:3:6, 1:3-½:5-½, 1:4:5. Seven-day strength results show that all mixes of the same proportion of cement to aggregate have substantially the same strength and also that the mixes with the most sand use the least amount of cement per cubic yard.

Notes in Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

VARIABILITY OF SUN'S RADIATION.

MR. C. G. ABBOTT of the Smithsonian Astrophysical Observatory gives an account of the results of investigations on the variability of the sun's radiation in a paper published in the Proceedings of the National Academy of Sciences for February, 1920. It is found that the investigations of the Smithsonian Astrophysical Observatory conducted at Washington, Mt. Wilson, Mt. Whitney, Bassour (Algeria), and now the investigations supported by the Smithsonian Institution from its private funds in North Carolina and Chile have all united in giving the impression that the solar radiation is not constant, but varies from day to day through a range of certainly five and possibly at times ten per cent. The conclusion that the sun is a variable star is confirmed in several ways, but most notably by the results of measurements made by the Smithsonian Astrophysical Observatory at Mt. Wilson, California, on the distribution of energy along the diameter of the solar image. These measurements indicate, as was well known before, that the edge of the sun's disc is less bright than the center, and that the contrast of brightness between the center and the edge varies according to the wave-length of light, being greater for short wave-lengths, less for long.

But the measurements of recent years have shown that not only is there a variation of contrast by wave-length, but also a variation of contrast with the time. The contrast in each wave-length is different for different days of observation and, on the average, for different years of observation. The changes of contrast have been compared with the changes of total radiation of the sun determined by the aid of the pyrheliometer and spectrobolometer, and it is found that there is a moderate degree of correlation between them. The correlation is of two kinds. For variations of long periods of years, high values of the solar constant are found associated with high values of contrast between the center and edge of the sun. On the contrary, for the short period variations of the solar radiation, occupying a few days, weeks, or months, it is found that high values of the solar radiation are associated with diminished values of the solar contrast.

The cause of this two-fold variation is reasonably explained. When the sun grows hotter and thus increases its output of radiation along with increased solar activity, as indicated by sun spots, prominences, and other visible solar phenomena, this would tend to cause a greater degree of contrast. For since if the solar temperature were zero there would be zero contrast, the higher the temperature the higher the contrast. But the sun is probably entirely gaseous, and certainly its outer layers are so, and these may become more turbid at times, just as the earth's atmosphere becomes more hazy at some times than at others. Accompanying increased turbidity of the solar atmosphere there would be found a diminished value of the solar constant of radiation. But since the path of the solar ray is oblique in the solar atmosphere near the edge of the sun, the path is longer there and the effects of the turbidity would be greater at the edges rather than at the center. Thus with the increase of turbidity the contrast of brightness would increase accompanying a diminished value of the solar constant of radiation. In this way it appears that the two-fold variations of the sun which have been found may be reasonably explained.

EFFECT OF MAGNETIC FIELD ON ELECTRIC FURNACE SPECTRA.

DR. G. E. HALE of the Mount Wilson Observatory communicates to the National Academy of Sciences Proceedings, February, 1920, the results of a study, by Arthur S. King, of *the effect of a magnetic field on electric furnace spectra.*

Investigations on the splitting of spectrum lines by the magnetic field have employed, except in rare instances, the electric spark as the source of light. It has proved impracticable to maintain an arc between the poles of a magnet, though an apparatus giving a succession of flashes has been employed. The flame, because of its weak luminosity, has but

limited usefulness. The electric furnace, if its size does not prevent its use in the magnetic field, will evidently do work not at present take neare of. While the furnace does not give the enhanced lines peculiar to the spark, the other lines shown by the arc and spark occur for the most part in the furnace spectrum. In addition, the furnace is found to show a large number of lines which are produced only with great difficulty by either the arc or the spark, and for which we have as yet no data as to their magnetic separation. A further advantage over the spark for the lines common to both is the extreme sharpness of furnace lines when the apparatus is enclosed in a vacuum chamber, a feature which should add materially to the definition of the Zeeman components.

Pending the construction of a more powerful apparatus, a simple tube furnace was arranged for use in a magnetic field. A graphite tube, 10 cm. long, was placed axially between the poles of a Weiss electro-magnet. The jacket enclosing the tube and the contact blocks at the ends were water-cooled. A field of 6,500 gauses separated the components of most lines sufficiently to permit measurements of fair accuracy and to show the characteristic features of the source. The spectra of iron and vanadium received the chief attention, and measurements were made for a considerable number of lines having well-defined components. A comparison of lines common to furnace and spark showed no difference either in the number and arrangement of components or in their separation in the two sources, the very different excitation in the two cases appearing to have no effect on the magnetic characteristics. The furnace and spark can thus be used to supplement each other in studying the magnetic behavior of all classes of lines. As was expected, separations were obtained for many characteristic furnace lines which the spark emits very faintly. An outstanding feature of these lines for the iron spectrum is a prevailing large separation and simple triplet structure. Lines of this class are often of special interest in the study of sun-spot spectra.

The furnace offers unique facilities for the production of the inverse Zeeman effect when a plug is placed in the tube. The absorption spectra resulting from this arrangement were discussed in the preceding communication. An extended study was made of the magnetic components given in absorption by this method. No difference was observed as to character or magnitude of separation as compared with the effects for the emission spectrum. A means of direct comparison with the magnetic effects for absorption lines in the solar spectrum is thus afforded, which may be expected to be very useful in tests as to polarization and other features at various angles to the lines of force.

CONTEMPORANEOUS EVOLUTION OF WARM-BLOODED ANIMALS AND OF FLOWERING PLANTS

IN the American Journal of Science for March, Mr. Edward W. Berry directs attention to the practically contemporaneous evolution of warm-blooded animals and of fruit- and seed-bearing plants and to the improbability of the evolution of the former had the latter evolution not taken place.

The point is made that no one heretofore has suggested the correlation of these striking events, which in each case represent the climatic development of the respective kingdoms.

As regards the known geological records the first mammals antedate the first birds and both antedate the flowering plants, and the last group furnish evidence of their late Mesozoic differentiation which the mammals do not, except as this is inferred from the sudden appearance of mammals in previously unknown variety in the early Eocene.

The actual ancestry of the flowering plants is still shrouded in the mists of ignorance. Historically their earliest appearance in the geological record is in later Lower Cretaceous time where they are represented by leaf remains and petrified wood. These earliest known types do not appear to be primitive, and the fact that they have been found in such widely separated regions as Europe, Greenland, North America, New Zealand and Australia justifies the assumption that they must have had an extended antecedent history running back well into the older Mesozoic, although they could not have become fully differentiated, abundant or varied in those earlier days.

A characteristic feature of the flowering plants, not shared by the members of any other plant phylum, is that the ovary is closed and that after fertilization it, together with various accessory parts, develops into a fruit or pericarp. The production of fruit, using that term in the technical rather than in the popular sense, is a characteristic feature of the flowering plants, and the mere fact that fruit is a vernacular as well as a scientific term lends emphasis to the point that Mr. Berry elaborates.

Plants, like all other organisms, are concerned chiefly with problems of nutrition and reproduction. The formation of seeds, an event which occurred during the Paleozoic, was an exceedingly great step in advance over the spore-forming habit of the earlier stocks—the present day dominance of the seed plants furnishing the proof of this statement, if proof be considered necessary. Fruit forming, which is of a different category from seed formation, is not only a protective device for the seeds with their concentrated food stuffs stored away for utilization by the germinating plantlet, but is also the great factor in distribution.

Turning to the geologic record of the warm-blooded animals, Mr. Berry notes that the oldest known bird, *Archaeopteryx*, partly reptilian in character, comes from the upper Jurassic and was a carnivorous type, as were also the toothed birds of the Cretaceous. There are no records of frugivorous birds, or in fact any modern birds until a time subsequent to the differentiation of numerous families of flowering plants.

The geologic record of the primitive mammals is exceedingly imperfect. The earliest known are recorded from the upper Triassic of Europe, North America (Keuper of North Carolina), and South Africa (Stormberg beds). Essentially similar Prototherian or Metatherian types are present in the Stonesfield slates and Purbeck beds of England, in the supposed Jurassic of South Africa, and in the Cretaceous of North America, and possibly Patagonia. They survived as the archaic mammals of the earliest known Eocene terrestrial faunas.

That the evolution of the higher plants was one of the important factors in the comparatively sudden efflorescence of the mammal and bird stocks, Mr. Berry maintains, cannot be doubted. The small Prototheria of the Triassic did not change greatly during the lapse of ages because the food supply did not change greatly and because of the competition for it of the reigning race of reptiles, and it may be suggested that the changing food supply, due to the evolution of the flowering plants and which is suggested as one of the important factors in the evolution of the higher mammals, was also one of the factors that spelled the doom of the overgrown and specialized Reptilia of the Mesozoic.

The earliest mammals appear to have been insectivorous. The various orders of insects are old geologically and that they existed comfortably before the higher plants were evolved is obvious, but that the latter became an attractive source of food and were the stimulus for very many new genera and species cannot be doubted. Thus indirectly the flowering plants greatly increased the food supply of the insectivorous mammals. The Rodentia, Edentata and Primates depend almost entirely upon the flowering plants for food, as do the Ungulata, and indirectly the Carnivora, since the latter group is chiefly dependent on the aforementioned groups and to a less extent upon birds or cold-blooded prey.

Upper Cretaceous floras furnish a large number of types of great food value, and among fruits—palm nuts, figs, walnuts, persimmons, etc. Very many fleshy fruits are found in the Eocene floras and these even include among their number such specialized fruits as dates and zapodillas (Eoachras). The Ptilodus skull described by Gidley (1909) from the Fort Union Eocene of Montana not only proved the marsupial character of that genus, but showed considerable dental speciali-

zation which his describer attributed to frugivorous habits.

The relatively sudden differentiation of flowering plants immediately antecedent to the equally sudden differentiation of the Eocene Mammalia was not fortuitous, but the two series of events are to be correlated. Both were largely accomplished during a time when the sea had retreated for the most part from the continents and land surfaces were much extended. This also was possibly an evolutionary factor in both kingdoms as were any climatic changes that may have taken place. It is clear that the long period of land emergence that intervened between the time of deposition of the latest Cretaceous and the earliest Eocene marine sediments in most regions was the theater of evolution of the modernized plants and animals of the Eocene record.

In conclusion Mr. Berry finds that it requires but little argument to prove that human civilization could scarcely have been attained but for the presence of the flowering plants. Although the pre-human and eohuman races were largely carnivorous and supplemented a diet of flesh, fish and fowl (including shellfish) by such fruits and seeds as nature furnished them, and although certain existing races, such as the Esquimaux, maintain themselves without agriculture, the civilization of history have all had their basis in an agricultural society, and all crop plants (except such unimportant foods as fungi, seaweed, etc.) of all races, ancient or modern, are angiosperms or flowering plants.

It is only by agriculture that large numbers in settled communities can be sustained and the flower of progress can bloom. Instances of the greatest production of concentrated energy are furnished by some of the grains, one-third of the total weight of the whole plant being represented by the concentrated foodstuffs of the seeds. Game, even as abundant and as stupid as was the bison of our western prairies, could not afford a basis for a civilization, and even in this instance it might be recalled that the basis of the abundance of the bison was the fodder furnished by members of the angiosperm alliance. Similarly the food of the camels, sheep, goats and horses of the nomadic races was this type of plant.

SECRET SIGNALLING BY LIGHT RAYS.

OF the numerous ingenious applications of scientific knowledge to the solutions of problems which were emphasized by the world war are the investigations of R. W. Wood on the sending and receiving of signals by means of light waves, both within and beyond the confines of the visible spectrum, merit attention. Ordinary parabolic mirrors are not suitable for sending signals over long distances, from the rear to the front, because the field covered by the cross-section of the inaccurate beam is so large as to incur the risk of including a portion of the enemy's trenches simultaneously with the proper receiving station. This prohibitive characteristic is entirely avoided in Wood's "flash telescope."

This apparatus consisted primarily of a telescope having a tungsten lamp at the common focus of the objective and ocular. The objective was a non-cemented doublet, of three-inch linear aperture, corrected to have the same focal length for the near infra-red and for a certain wave-length in the ultra-violet. The tungsten lamp was of the nitrogen-filled type containing a very short spiral filament. With the low power ocular employed, the total magnification produced by the telescope was about fourteen fold. The focussing was effected by moving the objective along its optic axis, the position of the lamp being invariable relatively to the telescope tube, etc. The filter wheel was placed between the lamp and the objective. By rotating this wheel so as to interpose the proper ray-filter in the path of the beam of light, it was possible to flash signals either with white or with infra-red, or with ultra-violet light. To use the telescope it was only necessary to point the tube in such a direction as to cause the image of the lamp filament to be accurately superposed upon the inverted image of the receiving station. As regards efficiency, the following comparative data may be mentioned. A parabolic reflecting lamp of 35 cm. aperture carries less than 10 km. The flash-telescope, when used in broad daylight, carries 30 km., while using less than one-half the power consumed by the search-light.

Some additional advantages of Wood's telescope are: (a) the beam of light is a very narrow cone (cross-section about 6 ft. at a distance of 1 mile) so that secrecy is assured; (b) the telescope can be aimed with great precision; (c) the instrument can be used as a receiver of signals sent out by a very distant station; and (d) ordinary displacements of the lamp with respect to the tube, arising from shocks incident upon transportation, have no deleterious influence on the accuracy of pointing. Case (d) does not hold true for parabolic reflecting lamps.

When conditions were such as to preclude the use of white signals in full daylight, the difficulty was overcome by employing radiations between L6900 and L7500. The ray filters were made, in the well-known way, by staining gelatin with appropriate aniline dyes. In general, the filter was compound, one gelatin sheet being stained with cyanin and the superposed plate with almost any deep orange coloring matter. The flash telescope was always provided with two infra-red screens, the brighter and darker filters being best suited for signalling over distances from two to six miles, and under two miles, respectively. By using spectacles or field glasses, etc., in conjunction with color screens of the same kind as in the sending apparatus, the dazzling daylight was decreased in intensity to a very much greater degree than the infra-red radiations, thus causing the distant signal lamp to assume the appearance of a brilliant star and approximately black landscape.

Secret signalling at night was accomplished by using ultra-violet rays. The filters consisted of circular disks of black glass having an oxide of nickel as the coloring base. The receiving apparatus was essentially a short focus telescope, of very wide aperture, provided with a screen coated with barium platino-cyanide and coinciding with a focal plane of the condensing objective. This screen was viewed through a small ocular. The ultra-violet light was not transmitted by the screen, of course, but the focal spot was made visible by the bright green phosphorescence of the barium compound. With the less dense filter signals where received at a distance of 5.5 miles, and with the deeper filters at 2.5 miles.

To establish large beacons or reference points for naval and aeronautical purposes the best results were obtained by using a quartz mercury arc covered with a screen of nickel glass. The small amount of red light which would be transmitted by this kind of glass is not emitted by the mercury arc so that, beyond very short distances, the screened lamp is not visible to the unaided eye. On the other hand, the powerful mercury line at $\lambda 3650$ falls exactly at the center of the transmission band of nickel glass. By employing an appropriate phosphorescent detecting apparatus, a lamp arranged in the manner just suggested has been seen by an observer in an airplane flying at an elevation of 3,000 meters.

In addition to the practical application of the ultra-violet lamp, the original paper contains an interesting account of certain striking phenomena which occur when various objects are illuminated with ultra-violet light of practically a single wave-length. For example, the lens of the human eye becomes phosphorescent. The skin assumes a peculiar hue, natural teeth phosphoresce brilliantly, false teeth appear black, etc. By using a very dilute solution of potassium chromate, the author has taken photographs (reproduced in the paper) of his face and of one hand. This filter transmits the radiations that excite the phosphorescent screen, but it completely absorbs the ultra-violet rays reflected and scattered by the skin. Old cicatrices, ordinarily invisible, come out with great distinctness. In this connection, the author suggests the possibility of taking advantage of these phenomena in physiological researches.—From *American Journal of Science*, March, 1920.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

FOOD ECONOMY.

FREQUENTLY in discussing the competition which the Oriental laborer gives the American workman we hear mention made of the fact that a small amount of inexpensive food seems to satisfy the man from the Far East; whereas, the American must have his meat and a fairly complete assortment of vegetables. The principal food of many thousands in the Far East is made up of rice and some product of the soy bean, with now and then a small portion of fish.

In studying the characteristics of the various varieties of bean it would appear that through investigation under the direction of Dr. C. O. Johns of the Bureau of Chemistry, Department of Agriculture, the scientific basis for the efficiency of the Oriental diet may have been discovered. One of the essential ingredients in the diet of man is protein. Recent researches have proven with experiments upon animals that it is not only important to have a sufficient quantity of protein, but it is essential, if body growth is to be promoted, to have particular kinds of protein. Many of the proteins will sustain the body, but they do not all yield the amino acids necessary for growth upon their being broken up by the digestive processes. The proteins are valuable because of these amino acids, and cystine seems to be the amino acid which exerts the greatest influence upon growth. It has been found that the beans most generally cultivated in our country do not yield this important amino acid and consequently will not promote growth. The Navy bean will maintain the body and will assist in the rebuilding of fatigued organs, but if children derived no protein from other sources than the Navy of lima beans their growth would be practically stationary. On the other hand, the soy bean, which is of Chinese origin, and the mung bean do yield this valuable acid, and being high in nitrogenous material the soy bean may almost be considered a complete ration. The mung bean is a leading ingredient in chop suey and is largely used by the Chinese in producing sprouts which are an ingredient in much of their food and which are rich in vitamines.

If the press cake from the soy bean oil presses is used with peanut flour and white flour to make a loaf of bread it is claimed that such a loaf is a complete ration and will be found more easily assimilated than meat and equally nutritious and sustaining. Moreover, the soy bean cake has a neutral flavor so that in it we have the possibility of an important food base without carbohydrates with which a great variety of attractive, nutritious dishes could be prepared, depending upon other materials to impart the desired flavor, form, and texture.

Of late an increasing acreage has been devoted to raising soy beans, particularly in the South where the boll weevil makes the cultivation of diversified crops a necessity. But we have not yet learned the use of the soy bean and its products in our American foods. The soy bean cake has been used as a fertilizer because of the high protein it contains, and more recently as a stock food for the same reason. It certainly would seem more economical to make this protein an article for direct human consumption, rather than take the roundabout way through the animal.

The variety of materials made from the soy bean and its products in the Orient is remarkable. It forms the basis for an artificial milk. It is fermented into a drink. It affords an artificial cheese and the casein recovered from it has a variety of application. It will be seen, therefore, that nature has been particularly good to the Orient and naturally provided it with a particularly useful variety of bean. Without knowing why, the Oriental has found that the bean is a satisfactory item in his diet and it appears that he has chosen his food upon a scientific basis. It remains to be seen whether Americans will be willing to act upon the information that has come to light, and in time make the soy bean as prominent an article in our commissary as the Navy bean now is.

A NEW TYPE OF CATALYST.

MR. BENJAMIN W. ELDER has secured patents covering a new type of catalyst which is suitable for hydrogenation. It is prepared by subjecting nickel to the action of silica, pumice, carborundum, diatomaceous earth or other very finely divided abrasive, and this action may take place either dry or in the presence of oil. The preparation made under oil is found to be more active. In the laboratory it has been found that if a plate of nickel be rubbed over another plate with oil and an abrasive between them catalytic nickel may be produced. On a commercial scale a porcelain lined pebble mill may be used in which nickel shot, the abrasive, and some oil, such as cotton seed oil, are placed. The action of the mill produces finely divided catalytic nickel suspended in the oil. There seems to be a direct relation between the activity of the catalyst, the fineness of the abrasive used, and the length of time the grinding is carried on.

The process appears to have considerable practical importance and at the same time seems to make it necessary to discard some of our former theories of catlysts. Thus the catalyst prepared by Mr. Elder's process is metallic, indicating that a sub-oxide nickel catalyst is not essential for hydrogenation. Also the theory that high temperatures if used in the preparation of metals for catalysts would render them unsuited must be revised, since the nickel shot used in the pebble mill has been heated above the melting point of nickel. Where nickel oxide is reduced to provide very finely divided nickel it has been demonstrated that low temperatures produce active and high temperatures inactive catalysts. This apparently does not hold where the metal itself is concerned.

HYDROCYANIC ACID GAS IN FUMIGATION.

MUCH has been written concerning the use of this deadly poison in fumigation, for there are many forms of pests which apparently cannot be entirely exterminated by any other means. This is true for instance with regard to the type of insect which sometimes infests libraries, there to feed upon the material found in the covers of books and the materials used in binding them. There is also no other way so sure to exterminate the moth, whose work may soon be regarded a mark of distinction since he prefers wool for his diet. In an effort to keep from our shores the pests of the cotton crop which infest the Egyptian cotton fields, all cotton imported from that part of the world is given a hydrocyanic acid gas treatment in a special apparatus designed to admit whole bales.

Unfortunately, so far as its application is concerned, the hydrocyanic acid gas is so poisonous that it cannot be used with the same freedom as we use other insecticides. Thus, if a house is to be fumigated with it great care must be exercised in effectively sealing doors, windows, and other openings, and the gas generators started in the attic so that the operators may rapidly work their way down and out of the house. Many hours must also elapse before the house can be entered again.

In the April issue of the Popular Science Monthly, a further use of hydrocyanic acid gas is described. It is proposed

to isolate diseased trees and those with pests not disturbed by other types of insecticides, by dropping a tent over them from a captive balloon.

Tanks of hydrocyanic acid gas can be brought to the location and the gas released beneath the tent with safety. After a fixed period of time, the captive balloon is brought back to lift the tent off and carry it away for a repetition of the performance.

BORAX IN FERTILIZERS.

The following note is from a recent issue of Chemical and Metallurgical Engineering:

Two pounds per acre of anhydrous borax marks the limit of safety with which it may be used in fertilizer when the fertilizer is put in the row so that seeds or plants are brought into virtual contact with it. This is the opinion of the specialists of the Department of Agriculture who have been studying the matter of borax in fertilizer. As a result the Department has advised all fertilizer manufacturers and dealers in fertilizer that more than two pounds of borax per ton of mixed fertilizers will not be allowed unless the presence of an excess of that amount is indicated plainly on the container.

When fertilizer is broadcasted and thoroughly mixed with the soil, the Department's specialists agree, ten pounds of borax may be contained in the fertilizer used on an acre of ground without danger to the crops. The Department describes the experience of farmers in some sections of the country as disastrous as a result of using fertilizer containing borax. It is to guard against a similar experience that the Department on December 9 put into effect its drastic regulations regarding the borax content of fertilizer.

Borax is described as being "highly toxic to crop plants," and was contained in the potash derived from at least one of the new sources which were resorted to after the war had cut off foreign supplies of potash. The Department also has ascertained that nitrate of soda as imported also contained some borax. The Department is also authority for the statement that borax was "not known to have been present in appreciable quantities in the materials commercially available for fertilizer uses prior to the war."

Recent research on potash materials from the source to which reference is made in the above is reported as successful in eliminating the borax so that it will be possible to supply material to specification. In view of this progress, it is to be regretted that the experience of last year will make it difficult to overcome the prejudice against his material, which has quite naturally resulted.

SCIENTIFIC CONTROL.

Whatever the attitude toward research may be in a given industry, it is usually not difficult to establish the desirability for scientific control which if it has any chance at all is pretty sure to be the entering wedge for research. There is a case of a concern which began with a two-man laboratory and today the Department of Research and Development occupies the entire building which was then the large new factory.

The investigation which goes with scientific control frequently uncovers valuable bits of information in unsuspected places. Working upon the measurement of the fiber spun in a cotton mill, an investigator found that whereas the mill purchased fiber which averaged an inch and a quarter in length by accurate measurement, it spun fibers averaging one and one-eighth inches. These measurements were made by means of a projection apparatus which threw the picture of the fiber upon a screen where it could be quickly measured with a reasonable degree of accuracy, so it did not depend upon the estimate of some one experienced in pulling the cotton to determine the length of staple. Further investigation proved that due to the way in which a part of the machinery had been set the fiber was actually being reduced in length as it went through the mill operations. Since the longer fibers bring a price above the base price fixed for shorter staple, it was obviously a large economical loss to purchase a longer fiber than was made and especially to purchase a long fiber only to shorten it in the machine operations. The textile industry is beginning to find that it has problems which may be solved by the application of science. A few of the mills have their own laboratories, but being unlike those industries founded upon a science this practice is not yet universal.

There is a very attractive research field in the utilization of a shorter staple. Of course a considerable quantity of this cotton is used now, but it seems probable that if we knew more about what takes place when the fiber is subjected to the various mechanical and chemical processes through which it passes that we could find ways of using the shorter fibers for some products for which at present the longer staple is considered an absolute necessity.

The clay working industries are among the most ancient of our civilization and the nature of the raw material makes it difficult to standardize and understand. The scientists have been at work, however, and those men who have been responsible for much of the progress are now calling to their assistance trained scientists for research and plant control.

The beauty of the work seems to be that the control laboratory soon finds the need of methods, data, and principles which have not been standardized or proven, and if in the right hands it begins sooner or later upon some small piece of research, which is pretty sure to be but the beginning of a large and ever widening program. There is danger, however, that control may be mistaken for research, but once convinced of the fact that science is the good investment claimed the far-sighted manufacturers prepare to go through with a well considered, broad plan of scientific work.

COAL TAR PRODUCTS IN THE RUBBER INDUSTRY.

In the Color Trade Journal for April, Dr. Frederick Dannereth dicusses the coal tar products used in the rubber industry and adds thereby still another reason for the passage of legislation now before Congress to encourage the establishment of an organic chemical and coal tar products industry in the United States. It should be emphasized again that a by-product of the dye industry is research in organic chemistry which is pretty certain not to be carried out otherwise. Further, it produces men with just the experience necessary for the conduct of a variety of organic chemical industries.

The article states that the coal tar products used in the rubber industry include the following: vat dyes for coloring rubber compounds; insoluble azo colors formed directly in the rubber; volatile liquids used in preparing rubber cements and as solvents in vulcanization by the cold cure; pitch products used as porosity corrective. Naphthol and amino phenol used as coagulents for latex, amino benzene derivatives are the accelerators of vulcanization and amino derivatives are used as the devulcanizing agents for waste rubber. Then we have cresols in reclaiming waste rubber goods, coal tar used in softening reclaimed waste rubber, and lamp black used as a filler and a pigment.

The accelerators of vulcanization have been the subject of much study of late and it is now practically agreed that the amino derivatives so used function generally as catalysts, which assist in carrying the sulphur to the rubber molecule. The use of an accelerator means that rubber mixtures may be vulcanized in 30 minutes, instead of two hours as formerly; so that three or four times as many tires may now be vulcanized with the same equipment. A better appreciation of what this means may be derived from the fact that there are tire factories producing from 15,000 to 20,000 tires per day. There has been some danger to the health of workers in the use of these organic accelerators, but this is said to be due largely to the older types of mixing machines now being gradually replaced by modern devices, in which the rubber, fillers, sulphur, and the accelerators are placed in the kneader and the machine closed and kept closed until a homogeneous compound has been obtained.

Dr. Dannereth, in discussing cements, points out that it is incorrect to refer to such materials as carbon bisulphide, carbon tetrachloride, petroleum, naphtha, etc., as solvents for rubber compounds for actually something less than one per cent of the rubber goes into solution. It is more proper to refer to these liquids as thinners. The manufacture of rubber cements consists in grinding the raw rubber or the rubber compound into a paste with the thinner, remembering that the mixture is highly inflammable. With such mixtures thin films of rubber may be obtained, and to enable the operator to work rapidly it is an advantage to use thinners having a high rate of evaporation.

The devulcanization of rubber compounds and the recovery of the used rubber contained in them is constantly becoming a more important field. Experiments have indicated that more than half the combined sulphur may be removed from a rubber compound and more lately a patent for a process of devulcanizing covers the absorption of the sulphur with some reagent, such as sodium, as rapidly as it is liberated by an amino substance.

THE ISOLATION OF VANADIUM.

How many motorists give any thought to the work which is done by scientists in many parts of the world that they may have their convenience and pleasure? Vanadium in the form of ferro-vanadium has literally made some of the lower priced automobiles possible and has also contributed directly to the production of more imposing cars since ferro-vanadium may be used in high speed tool steels, in the larger locomotives, and in special types of rails. Ferro-vanadium offers strength and durability with light weight, and being readily machinable requires but half the expense to produce an automobile part compared with its production from high carbon steel.

However, vanadium may be considered isolated since the only known large concentrated deposit of pure ore is to be found in the Peruvian Andes, nearly 17,000 feet above sea level. To date the ore has been brought out in 125 pound bags on the backs of llamas. The mine in question has constituted the commercial enterprise conducted at the highest altitude in the world. There have been a number of factors which have made it difficult to increase the output of ore to keep pace with the present demands for vanadium.

Americans are now building a railroad to this deposit and this feat involves overcoming extraordinary engineering difficulties. With the completion of this line the output of the mine will be greatly increased and eventually it is thought the price of vanadium may be lowered in consequence, although even now the price is but a fraction of that obtained for it when vanadium was discovered nearly 30 years ago.

GAS AS A FERTILIZER.

IN studying the elements which control the growth and production of plants at a time when it was difficult to secure sufficient fertilizer of different types, German chemists, working under pressure to produce the maximum quantity of food possible, turned their attention to the air. We know that plants breathe just as animals do and that carbon dioxide ordinarily present to the extent of 3-100 of one per cent in the air is essential to plant maintenance. Reasoning that since plants do so well on but three parts in 10,000 of carbon dioxide, and they might do better in the presence of a greater quantity, it was decided to try the experiment, using the carbon dioxide, which is a by-product in the production of pig iron.

During the production of 1,000 tons of pig iron 1,000 tons of coke are consumed, and 4,000 tons of carbon dioxide gas are turned into the air. If all of this carbon dioxide could be used, calculations indicate that about 4,000 tons of vegetable matter would be produced, and if even a small percentage of the gas were utilized the results might very well justify the cost incident to the distribution of the gas.

In Germany the experiments were begun in hot-houses and in a few days results were noticeable. Those plants receiving a higher percentage of carbon dioxide grew more luxuriantly, bloomed earlier, matured more rapidly, and gave an increase in yield. Thus, tomatoes increased 175 per cent in their yield and cucumbers 70 per cent, as compared with those grown at the same time under normal conditions. In order to extend the experiments to outdoor plots, perforated pipes were laid so that the gas could escape slowly in the vicinity of the plants, and, although much of the gas would of course escape, yields were obtained that could only be explained by the fact that the gas was used. Two bushels of barley grew where but one had grown before. Potatoes increased 150 per cent in yield and spinach did even better, producing 154 per cent of the crop grown on controlled plots under normal conditions.

It is reported that in 1918 seven acres were equipped with pipes to distribute the carbon dioxide and that on this larger area the substantial gains reported above were maintained or even increased. In one case, a crop that showed an increase of 18 per cent by the use of ordinary commercial fertilizer increased 82 per cent when both soil and air were fertilized. Of course gaseous fertilizers alone could be of but little consequence, for the plant must have the mineral salts, the nitrogen, and ammonia, which we know to be necessities for a good crop. It will be interesting to consider the possibilities in centers adjacent to manufacturing establishments where carbon dioxide is a by-product, and in those vicinities an increase is usually a vital thing. It is to be hoped that similar experiments at least to check the claims made by foreign investigators may be undertaken in our own country.

RAILROAD HELIUM REPURIFICATION PLANT.

As the cost of production of helium is high, a repurification plant has been designed to be carried by two standard 70-ton railroad cars, and to operate continuously with a capacity of from 1,000 to 2,000 cu. ft. per hour.

The plant is described in the *Aircraft Journal*, Jan. 24, 1920. The power plant, a 120 hp. heavy duty gasoline engine connected to a direct-current generator, together with fuel and sleeping quarters for the crew, is situated in one car. The other car contains all the repurifying apparatus, consisting of electrically operated air and gas compressors, purifying column, manifolds, charging and discharging desiccators, cooling tower, water supply tanks, gasometer, testing apparatus, etc. The operation of repurification consists of the reduction of temperature and pressure of the impure helium until the impurity (air) is liquefied and drawn off, allowing the pure helium to escape as gas.

CHEMISTRY IN PLANT DISTRIBUTION.

MR. E. T. WHERRY in recent addresses has indicated something of the narrow limits in which science must work to be of the greatest use in special cases. As early as 300 B. C. observations were made that plants seemed to bear certain relations to different ores or soil compositions and the names of certain species may be traced to the preference which such plants seem to have for certain of the metallic elements. Of late some of the botanists reached the conclusion that the chemical nature of soil has no influence upon plant distribution and this undoubtedly has seemed to be true in the light of our data based upon older methods of analysis which did not permit determining the very small differences in soil acidity, which may now be discovered by means of a new series of very sensitive indicators.

These indicators were first studied in connection with bacteriological requirements, where the degree of acidity in the media is a very important factor. A series of dyes has been selected such that the hydrogen concentration can almost be found quantitatively by the color with this range of indicators, which behave differently as the concentration of ions increases

or diminishes. The preference of certain plants, such as the heath family, for soil largely composed of decayed wood has been traced to the increased acidity of such soils. Mr. Wherry related one example where growth about a rotted log tended to confine the soil so that it was three times as acid as water which flowed adjacent to it.

It has also been demonstrated that methyl red has the right range of color changes to indicate whether or not a given soil is sufficiently acid to grow scab-free potatoes. By taking a small sample of a selected soil, shaking it with water, and allowing the mixture to settle, the supernatant fluid may be decanted and a few drops of the prepared indicator added. If the color of the fluid is then orange or yellow it is a clear indication that the soil is not sufficiently acid, but if it be red or violet red, potatoes may be planted in it with the assurance that they will be scab-free. It is possible to conduct all of such tests in the field using distilled water, of which but a small quantity is necessary, and the indicators, a set of which may be silpped into the pocket.

The study of acidity and alkalinity of soils with these new indicators is still under way and it will be seen at once that there is a direct relation between this work and maximum plant production. Of course it will be some time before it becomes the practice of those who now do their planting according to the phase of the moon to resort to test tubes and hydrogen ion indicators to guide them in their agriculture, but all work of this kind assists us in understanding more of nature's ways and perhaps ultimately in formulating national food production plans.

AMERICAN CHEMICAL SOCIETY.

THE spring meeting of the American Chemical Society has just been held in St. Louis with an unusually large attendance of men from all over this country and abroad. The Society has become the largest scientific society in the world devoted to a single branch of science, its membership now being approximately 15,000. As usual, a number of interesting papers were presented in the eleven divisions and sections of the Society, some of which included more than fifty papers in their program. New sections are those devoted to leather chemistry and to sugar. There is a possibility in the near future that a section devoted to cellulose chemistry may be formed.

One subject which engages the attention of the chemical profession today is the supply of properly trained men, which depends upon maintaining in our professorial chairs and in all teaching positions men and women who are really qualified to teach chemistry and the allied subjects. It is becoming increasingly difficult for our educational institutions to maintain an adequate staff of teachers. Men are constantly leaving the classroom for the industrial laboratory, and the question of our future supply of chemists is becoming more and more a serious one. One method suggested at the meeting involves securing funds from which various payments can be made for the published researches of outstanding quality; these payments to be of a size making it a prize well worth the effort, offering an opportunity for the research men in the educational institutions to make substantial additions to their present income. The practicability of the proposed scheme is now under the consideration of the Committee appointed for the purpose.

A discussion of the present economic status of the chemist brought to light data which should be encouraging to the young men about to enter the profession. While the statistics available were gathered from only a few hundred reasearch men, they show that the chemist today is undoubtedly earning on the average as high a wage as does the average of those found in the other learned professions while a few competent chemists are required to go through the sort of "starvation stage," which in the past has been the doorway to a career in some of the other professions.

Many of the papers in the different fields of chemistry will appear in the publications of the American Chemical Society, notably the *Journal of Industrial Engineering Chemistry.*

THE COW AS A LABORATORY.

UNTIL recently it would have been difficult to interest the stockmen in a study which had for its purpose determining whether it is better to feed an animal to be killed for beef or one which converts its food into milk, rather than into its own body tissue. There are perhaps several reasons for this, one being the difficulty experienced in some quarters in marketing large quantities of milk to advantage, but with the change in conditions which has emphasized the importance of condensed, evaporated, and dry milk it is conceivable that the question of whether it shall be animals for beef or a dairy that is to be supported may confront many a raiser of stock.

Dr. H. P. Armsby, an expert in animal nutrition, estimates that the energy of grain used in feeding the animal is recovered to about 18 per cent in milk for human consumption, but only about three and a half per cent of this energy reaches us in beef. An English official report states that the production of 100 calories of human food in the form of milk from a good cow requires that the animal be fed the equivalent of 2.9 pounds of starch. If a poor cow is maintained, the equivalent of 4.7 pounds of starch must be fed to secure the 100 calories in the form of milk; but if 100 calories in the form of beef is obtained from a two and a half year old steer, it has been found that the equivalent of 9 pounds of starch have been required to produce it. This would mean that a good milk cow returns 20 per cent of the energy value of that which she consumes, the poor milk cow 12 per cent, and a good beef steer but 6 per cent. Thus a poor milk cow is twice as efficient as a good beef steer, while the good milk cow is more than three times as efficient as a converter of energy from the form unsuited to human uses to that which is available for human food.

Professor Wood, a leading English agricultural expert, has determined that during the whole life of an animal, a cow returns one-twelfth as much food as she has consumed; this return being in the form of milk, veal, and beef. The beef animal returns but one-sixty-fourth, or but one-fifth as much during its whole life as does the cow.

It is apparent from this that when the price for animal feed-stuffs soar we should give more consideration to the efficiency of the laboratory to which we will take this raw material to be converted into human food. It also has a bearing upon the length of time the stockman can afford to fatten his animals for the market.

These considerations are based on protein fat and carbohydrate, but when we consider vitamines and mineral elements the cow has an added advantage. When beef animals are fed upon hydrocarbons and the usual parts of grains which furnish vitamines these are stored in the animal's tissues to but a slight extent, but they pass on in abundance to the milk so that coarse foods and grains not suitable for human food are converted into a form which makes it readily available in milk, though not in beef. Meat is also poor in calcium, which is comparatively abundant in milk.

These facts would seem to support the contention that a greater use of dairy products, rather than an increase in the consumption of meat, would become an economical procedure both for American agriculture and for the American consuming public. However, we need to know more concerning the problem of animal nutrition and its relation to the production of human food, considering the animal as a laboratory or plant in which the conversion from the inedible to the edible from the human standpoint can be accomplished. There are, however, a number of substances suitable for human consumption which find their way into stock feeds, and the proper use of these materials requires a long time study. The Committee on Food and Nutrition of the National Research Council is inviting support for this important program of investigation.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SELF-BAKING ELECTRODES.

A DECIDEDLY novel development was introduced in a paper by Prof. Joseph W. Richards, Lehigh University, on the Södeberg self-baking, continuous electrode. C. W. Södeberg, Christiania, Norway, imagined over ten years ago a self-baking electrode formed continuously from soft carbon mixture, which would be baked in the same furnace in which it is used and thus provide a continuous electrode. The first electrode of this kind was built by Mr. Södeberg in 1909. He naturally met with many difficulties in developing his idea and it was not until 1915 that he actively pushed the development in connection with the company with which he is now engineer. After considerable development work the company succeeded in overcoming in a practical manner all of the difficulties, and in November, 1918, a 400-mm. (16-in.) electrode was operated on a ferromanganese furnace without disturbances to the furnace and with no fracturing of the electrode. Since that time electrodes of all sizes up to 850 mm. (34-in.) diameter have been successfully operated, both in open and closed furnaces, in making ferrosilicon, silicomanganese and ferromolybdenum.

Dr. Richards said he saw last summer a 34-in. electrode of this type operating in a ferrosilicon furnace in Norway, the inventor of the electrode being his personal friend. The electrode is consumed very slowly and takes about a week to bake one meter. Several European firms are soon to make use of this type of electrode.

In the United States the new device is about to be tried out at the Anniston Steel Co., Anniston, Ala., on three furnaces, and a representative, Mr. Wesley, of the Norwegian interests, is now in this country overseeing the trial. There are to be at Anniston three 32-in. self-baking electrodes on ferrosilicon furnaces, and they are expected to be in operation soon. It is stated that any one desiring to see them will have the privilege.

During the discussion that followed Dr. Colin G. Fink of New York called attention to some advantages not presented by the author when he said that the new type evidently does away with the transportation problem and the spalling of modern electrodes if not stored properly. L. E. Saunders, Alundum Co., Niagara Falls, asked for information regarding the smoke from the baking of these electrodes and what could be done in case the iron casing used should contaminate the product. To this Dr. Richards replied that the baking is so slow there is virtually no smoke. What there is seems to be forced down into the interior of the electrode where carbon is perhaps deposited as the smoke comes in contact with the red hot carbon. If applied only to ferroalloys, contamination from the iron casing is out of the question, even in making calcium carbide it is claimed that the casing introduces no more than 0.20 per cent of iron into the product. Where aluminum is to be refined or melted, an aluminum casing might be used.—Meeting of the American Electrochemical Society at Boston, April 10, 1920. *Iron Age*, April 15, 1920.

TIDAL POWER.

OWING to the scarcity and high cost of coal, tidal power developments now come within the range of commercial possibility. In the *Electrical Times* of December 11, 1919, a proposed tidal development at Hopewell (England) is described. The data given for this scheme provides a basis for consideration of an entirely different method of development which is described below:

Broadly speaking, this system consists in dividing a tidal estuary into two or more basins by means of dams, in which turbines and generators are installed; sluice gates control the water, and the turbines are operated during the ebb and flow of the tides. During the flow the tide is allowed to rise outside the reservoirs until an adequate head to drive the turbines is reached, when it is passed through them, filling the reservoirs, until it turns and starts to fall. The sluice gates are then shut until the ebbing tide has fallen sufficiently below the level of the water now impounded in the reservoirs to produce the requisite head again to drive the turbines, through which the impounded water is then drained off until the tide again turns and starts to rise. During the period that elapses before the requisite head is reached to drive the turbines, after the turn of the high and low tide, power is produced by water filling into or draining from a subsidiary reservoir or reservoirs.

On the basis of the above system several schemes are presented diagrammatically by the author. Under scheme No. 1, for instance, the turbines operate through four cycles produced by means of a main reservoir marked A and a subsidiary reservoir marked B. Times are reckoned from low tide, which is considered as "zero" hour. The operation of the plant should now be traced through the four cycles.

Cycle 1. Main turbines run from 2 to 6½ hours by tidal water filling reservoir A direct.

Cycle 2. From 6½ to 8¼ hours subsidiary turbines take the load, being operated by water filling reservoir B from reservoir A, while the tide outside is falling.

Cycle 3. From 8¼ to 0¼ hours the main turbines are once more run by the water impounded in reservoir A, draining back to the sea simultaneously with the dropping of the tide.

Cycle 4. From 0¼ to 2 hours the auxiliary turbines again take the load, being operated by water in reservoir B draining back to reservoir A, which is then practically empty, while the tide outside is rising sufficiently to produce the requisite head for a fresh series of cycles to commence.

A power development such as that at Hopewell could be started on the lines indicated in the above scheme by providing dams and sluices sufficient to control water levels up to the full capacity of reservoirs A and B and by installing turbines and generators sufficient only to meet first requirements. The production of 700,000 horse-power is possible at Hopewell.—A. Struben, *Electrical Times*, London, February 26, 1920. Vol. 57, pp. 171-73.

CARBON ARCS FOR SEARCHLIGHTS.

AT the request of the British Admiralty a series of experiments were undertaken with the object: (1) of developing the best method of testing carbons in order to prove their value for searchlights; (2) of comparing the relative qualities of existing carbons, other than flame carbons, for producing high-intensity searchlight beams; (3) of determining what improvement can be made either in the carbons themselves or in the methods of burning them.

It was at first proposed to make measurements of illumination at different parts of a searchlight beam under actual working conditions in the open, but the sources of errors encountered were so great as to cause this method to be abandoned in favor of an indoor method of test, at any rate for the first series of experiments. The laboratory equipment consisted of an integrating photometer of cubical form fully described in the paper, and simultaneous measurements were made of the total flux of light emitted by the carbons alone and of the intrinsic brightness of the positive crater.

By this method a comparison was made of 13 different types of carbons, both those already in use in the British and French services, and others specially prepared by the General Electric Company. Experiments were made with two devices having for their object the control of the arc and its maintenance in a central part of the crater to ensure even burning of the carbons. One of these was an electromagnetic device, while the other depended upon a slow rotation of the positive carbon. For high current densities (0.3 amperes per sq. mm. and over) it was necessary to copper both positive and negative carbons. It was found that while change of potential difference on the arc produced no definite detectable change of candle-power, an increase in arc length beyond a certain value produced a decrease both of crater brilliancy and of candle-power. It seems likely that if allowance is made for the light obscured by the negative carbon, the shortening of the arc will be found to produce an increased average candle-power even at short arc lengths, but the exact amount of the obscuration is difficult to determine with accuracy.

In general it seems to be clearly established that for any one carbon the candle-power increases linearly with the current, while the crater brightness also shows a real increase, though its magnitude is not sufficient to determine the form of the relationship in this case. For the types of carbons considered, and apart from smoothness of running, there seems to be no definite difference of any magnitude either on average candle-power or crater brightness for carbons of the same diameter run at the same current. The efficiency in candle-power per ampere increases, however, for the same current density as the diameter of the positive carbon increased.—C. C. Paterson and others. Journal of the Institution of Electrical Engineers, January, 1920. Vol. 58, pp. 88-97. Discussion, pp. 97-106.

NEW PRIMARY BATTERY—AN AIR DEPOLARIZER.

M. FÉRY, Professor of the Municipal School of Physics and Industrial Chemistry of the city of Paris, designed a cell of interest in view of the novel method of dispensing with the use of the dioxide of manganese depolarizer in the Leclanché type of primary cell. The positive electrode of the new cell is a vertical cylinder of carbon of a somewhat porous nature. The negative electrode consists of a zinc plate placed horizontally at the bottom of the cell, and the exciting liquid is a solution of sal ammoniac. The porous carbon plays the rôle of a catalytic agent between the oxygen of the air and the hydrogen issuing from the electrolyte. The atmosphere is, therefore, utilized as a depolarizing agent in the action of the battery. This depolarizing operation is facilitated by the remoteness of the zinc plate from the top of the cell, at which point the air contact occurs. Zinc being a metal very easily oxidizable would tend to combine with oxygen, and it would therefore be detrimental, both to the constancy of the battery and to the zinc plate, were the latter not placed at the bottom of the cell.

Arrangements were made by the French technical authorities to put the Féry cell under trial on telegraph and telephone circuits. In the latter case the cells were used as a local battery. The telegraph offices at St. Cyr were equipped with the Féry cell in September, 1918, since which date the batteries have rigorously remained constant. At St. Cyr, after 250 days of service, each of the zinc plates had only lost 8 grm. weight. The constancy of the Féry cell is an extremely important feature—a quality which is not obtainable with the use of the ordinary Leclanché battery.

The Féry cell costs less than a cell in which dioxide of manganese is used, and when the zinc has been absorbed by the chemical action a new zinc plate and a renewal of the sal ammoniac are all that need be provided in order to obtain the equivalent of a new cell. Both as regards prime costs and annual maintenance charges, therefore, the new cell is less expensive than the manganese sac type of Leclanché battery. The French authorities have been impressed with the results of these experiments and have expressed the opinion that the cell should be employed in both the telegraph and the telephone services.—Annales des Postes, Télégraphes et Téléphones.—Journal of the Post Office Electrical Engineers, April, 1920.

EARTHING.

A SUB-COMMITTEE of the Institution of Electrical Engineers was asked to consider the whole question of earthing, including the time element of circuit breakers, the heating of conductors, the current-carrying capacity of the apparatus earthed, the drop of pressure in metal sheating and the number of earth wires required. In accordance with these instructions the sub-committee had performed considerable experimental work and recently brought in its report making the following recommendations:

1. Earthing conductors must be of the numbers and sizes set forth in the tables attached to the rules for each size of working conductor.

2. They should be of high conductivity copper, tinned or otherwise protected against corrosion, and protected against mechanical injury.

3. The smallest allowable size of earthing conductor should be 1/14 S.W.G., and the largest individual conductor should be 19/17 S.W.G., and that all conductors larger than 1/14 S.W.G. should be stranded.

4. When a larger section of earthing conductor than 19/17 S.W.G. is necessary, separate conductors must be used, and if earth plates or cylinders are employed, separate ones for each conductor must also be used.

5. Buried earth plates or cylinders must have an earth contact of not less than 4 sq. ft., and be surrounded on all sides by not less than 12 in. depth of finely broken coke. They should preferably be of cast iron or other durable metal, and the place selected for burying them must be permanently wet or, at least, damp.

6. Wherever an earth wire is connected to a pipe, or conduit, or cable sheath, or armoring, a substantially designed clip must be used. Sweating sockets also must be used at each end of the earth conductor for all sizes larger than 1/14 S.W.G. For armored cables substantial clamps must be used, so designed as to grip firmly the whole of the wires of the armoring without damage to the insulation.

7. Where special earth plates are not provided extreme care must be taken to see that only such earths are used as are easily capable of carrying the maximum current which can be allowed to flow by the largest fuse used in the circuit in question. From this point of view water pipes directly in connection with the street water-mains make excellent earths.

In conclusion, the sub-committee strongly recommends that the British rule providing for the need of earthing all metal other than the conductor on circuits where medium pressures are used be extended to include low-pressure circuits also, and that it also be extended to prescribe the earthing of all metal liable to be electrically charged, such as constructional steel work.—G. S. Ram and others. Paper read before the Institution of Electrical Engineers.—*Electrical Review*, London, April 9, 1920, pp. 476-79.

MOTOR BUSES OR TRACKLESS TROLLEYS.

IT has been demonstrated that the gasoline bus can be a worthy competitor of street railway systems by providing a higher class of service and charging a correspondingly higher fare. The Fifth Avenue buses of New York City and the Chicago buses are examples of such successful operation. However, experience has proven that it cannot compete in operating costs with an electric street car and cannot maintain an equal service at an equal fare, that it is unsuitable for dealing satisfactorily with heavy town traffic, that it is not adequate for dealing with peak loads and that it has no advantage over the electric car as regards schedule speed. It is then doubtful whether the gasoline bus will ever displace the street car; but this bus with very little change

from standard automobile construction can be converted into a trackless trolley, driven by railway motors, supplied with power from two trolley wires. The trackless trolley, which is a vehicle practically unknown in this country, is making an exceptionally good record for earnings and service abroad. The operating costs of such a trolley as compared with those of the gasoline bus and of the most efficient street car, the safety car, are given below:

	Cents Per Bus Mile		Cents Per Car Mile
	Gasoline Bus	Trackless Trolley	Safety Car
Maintenance of overhead	.....	0.5	0.5
Maintenance of way	.....	.....	1.5
Road taxes	0.75	0.75	.....
Maintenance of equipment	8.54	3.0	2.0
Platform expenses	8.0	8.0	8.0
Traffic expenses	0.04	0.04	0.04
Power	4.54	1.8	1.8
General	3.54	3.54	3.54
Depreciation	6.59	2.00	2.00
Total	32.00	19.63	19.38

Thus it is seen that the trackless trolley can compete with the street car. It could be built with approximately the same capacity as the safety car for a weight not to exceed 12,000 pounds, or approximately 25 per cent of the weight of the present safety car. A single motor drive with necessary control can be supplied which will permit the adoption of all the safety features now standard for the safety car. It is argued that the bus has the advantage over the trackless trolley as regards unlimited flexibility. There is little question, however, but that with the introduction of the gasoline-propelled bus the city authorities would insist on a definite route and a definite time table and, thus, it would be bound to a specified routing by ordinances or legislation as a trackless trolley would be by the reason of the overhead construction. With proper overhead construction and proper collectors, the trolley bus can have a range of operation of 15 feet either side of the trolley wires, which is ample to permit passing other traffic.

These estimates would illustrate that a bus similar to the gasoline-propelled bus could enter the urban transportation field and become a worthy competitor of the street railway system, giving equal service for equal fare. This is particularly true where the officials of railway companies have not profited by the experience gained in the application of the safety car and have not applied its principles to their transportation problems. The trackless trolley having lower operating cost than the gasoline-propelled vehicle will be successful where a gasoline bus could not operate. It seems, therefore, desirable that railway operators study their transportation problems with a view to utilizing the trackless trolley as an auxiliary to their present transportation system rather than to meet it in competition.—H. L. Andrews, *General Electric Review*, April, 1920, Vol. 23, pp. 331-334.

BRONZE PLATING

BRONZE, a copper-tin alloy, can be plated or deposited from a bath containing potassium hydroxide 5 per cent, potassium cyanide 0.5 per cent, ammonium stannic chloride 0.38 per cent, and potassium copper cyanide 1.5 per cent. Satisfactory corrosion of bronze anodes is obtained, using a temperature of 40° to 50° C., and current density of 0.4 amp. per sq. dm. (3.75 amp. per sq. ft).

Bronze can also be deposited from a bath containing copper oxalate and tin oxalate dissolved in ammonium oxalate, together with some potassium sulphate, citric acid and ammonium citrate or similar salts. Bronze anodes will not corrode properly, hence copper anodes must be used. The tin content of the bath can be maintained by regularly precipitating the copper from a portion of it by using metallic tin. A careful adjustment of the relative quantities of copper and tin in the bath is necessary. Most trouble is caused by the poor corrosion of the bronze anodes.—F. C. Mathers and Stanley Lowder. Paper read before the American Electrochemical Society, April 10, 1920.

DESULPHATION OF POSITIVE PLATES.

THE Kansas State College has devised the following method of treating the positive plates of lead cells that have become sulphated:

Remove the electrolyte, wash out the cells thoroughly with distilled water, replace the electrolyte by a 3 to 4 per cent solution of caustic soda, charge until the positive plates have regained their brown color. Sufficient soda should be added so that the solution does not become acid.

The process is said to be harmless to the battery.

CONSTANT POTENTIAL SERIES LIGHTING

UNTIL recent years street lighting in the United States has been almost exclusively by the high voltage constant current series system. This was mainly for two reasons: To the democratic character of the country only such form of lighting appeared suitable as was applicable alike to the scattered suburbs and to the more densely populated center of the city. The other reason was the electrical characteristic of the arc which was the only illuminant of sufficient intensity and efficiency for street lighting. However, with the gradual disappearance of the arc lamp disappeared the necessity of the constant current circuit. The gas-filled mazda lamp is taking the place of the arc lamp. This mazda lamp represents a dead resistance, equally stable on constant potential as on constant current, and while the necessity of using high voltage still remains, especially in American cities with their large street-lighting districts, the need of the constant current system has ceased, and high-voltage constant potential series system becomes possible.

The foremost disadvantage of the constant-potential series system is its lesser flexibility; in such a system the number of lamps is given by the circuit voltage. Thus from a 2,300-volt constant-potential supply could be operated $2300/45 = 51$ 300-watt 45-volt lamps, neither more nor less. This limitation is overcome by the use of transformer taps and idle regulating reactors which can easily afford a 20 per cent range of load, and this would probably be sufficient for most purposes. A further disadvantage of the constant-potential system is its sensitivity to grounds. If two dead grounds occur in the same circuit, the current in the remaining part of the circuit is increased, and if the short-circuited part of the circuit is considerable, all the lamps in the remaining circuit may be burned out. How serious this is depends on the quality of the circuit. However, with any reasonably well built and operated circuit, the probability of two dead grounds in the same circuit should be so remote as hardly to require much consideration.

On the other hand, the great advantage of the constant-potential series system is its high power factor of 95 to 99 per cent, the better efficiency, and especially that it requires no station apparatus, such as constant-current transformers, but can and would be operated from a transformer on a pole in the distribution system, just like domestic lighting, and the mass of lines or cables running back to the stations, which are characteristic of the usual constant-current systems, due to the limited power per circuit, thus is eliminated.

In such constant potential series of lighting system all the street lighting, all the street lighting circuits may be operated from one single feeder or a few feeders which are connected or disconnected from the station at the proper time, a still more simple and convenient method is to connect the constant-potential transformers on the poles in the street lighting district, which operate the street lighting, to the domestic lighting feeders in their respective territory. This latter, however, requires some means of connecting and dis-

connecting the street-lighting transformers at the proper time of starting or stopping the street lights, since the domestic lighting feeders are continuously alive. Such may be done by manual operation, or by cascade operation; also time switches or pilot circuits may be used. Still another method which in many cases is very promising is the use of the phantom switch, that is, a switch operated with direct current by a polarized relay, so that one direction of the direct current closes it, the opposite direction opens it, with the direct current sent to the switch, such as are extensively used in telephony. Such arrangement permits electrical long-distance operation without any additional circuit.

Comparing then the three types of high-voltage street-lighting systems, the constant-current series system, the constant-potential series system and the constant potential multiple system, we have:

	CONSTANT-CURRENT SERIES SYSTEM	CONSTANT-POTENTIAL SERIES SYSTEM	CONSTANT-POTENTIAL MULTIPLE SYSTEM
(1) Type of lamp	Arc lamp or incandescent lamp	Incandescent lamps only	Incandescent lamps only
(2) Station apparatus	Constant-current transformer or reactor, etc.	No station apparatus	No station apparatus
(3) Number of station circuits	A separate circuit for every lighting circuit	No special circuit from station	No special circuit from station
(4) Number of wires per circuit	Single-wire circuit	Single-wire circuit	Two-wire circuit
(5) Accessories at lamp	Film cut out, or auto transformer or series transformer	Auto transformer or series transformer	Constant potential transformer
(6) Size of circuits	Limited number of lamps per circuit	Limited number of lamps per circuit	Unlimited number of lamps per circuit
(7) Flexibility	Great flexibility in number of lamps	Lesser flexibility	Great flexibility in number of lamps
(8) Power factor	80 to 85 per cent with incandescent lamps; 70 to 75 per cent with arc lamps	95 to 99 per cent	Practically unity
(9) Safety	High voltage at lamps except when using transformer	High voltage at lamp except when using transformer	Low voltage at lamp

—CHARLES P. STEINMETZ, *Journal of the American Institute of Electrical Engineers*, March, 1920.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

POWER TRANSMISSION BY SONIC WAVES.

BY J. HERCK.

ALL methods of power transmission may be divided into three basic classes. First, the rigid transmission from solid body to solid body, as in gearing, bolt and other friction drive methods; next, transmission by fluid under pressure, no matter what the nature of the fluid may be—water, air or even electricity (direct current); third, so-called sonic waves of M. Constantinesco, a Roumanian engineer, who is said to have spent close to twenty years in the development of his idea.

The employment of sonic waves is based on experimental work which is said to have demonstrated that, contrary to popular impression, liquids are essentially compressible.

Let us consider now a conduit having a piston at each end, A and B, and entirely filled with a liquid, the pistons being leak-proof. If, now, the piston A is given a sudden impulse the liquid will be compressed, the volumetric compression storing up in the liquid a quantity of energy proportional to the coefficient of elasticity of the liquid. Furthermore, since the deformation produced is assumed to have been sudden a wave is created in the liquid and moves through it with the velocity equal to $\sqrt{\frac{E}{m}}$, where E is the coefficient of elasticity of the liquid and m is the mass per unit of volume; this velocity is the same as the velocity of propagation of the sound in a given liquid.

If the length of the conduit be properly selected, the wave will cause the piston B at the other end to move and if a vibratory motion be imparted to the piston A the piston B will receive the same motion, the conditions being somewhat analogous to what takes place with single-phase alternating current in electricity.

The intercalation of an auxiliary reservoir creates a capacity having the same effect as a condenser in an electric circuit; a spring in the circuit, by its inertia, performs the same functions as a self-induction coil, and the resistance in the conduit to the passage of the wave reminds one of an electric reactance, while the average pressure produced may be compared to the voltage in an alternating-current circuit.

The tube itself, which must be sufficiently thick not to burst under the pressure produced, introduces an accessory capacity which should be taken into consideration in the same manner as the capacity of a submarine telegraph cable is considered.

The analogy between the sonic waves and the transmission of power by alternating current can be carried still further. If we take three conduits interconnected between them and having impulses spaced 120 deg. apart, we obtain three waves spaced likewise 120 deg. apart and we have something similar to three cables carrying the three-phase alternating current—in this case only sonic instead of electric. All that is necessary to create it is three pistons placed star-wise while at the receiving end two arrangements may be employed depending on whether it is desired to have a synchronous or asychronous motor. The original article shows several diagrams illustrating the principle of these constructions.

It is interesting to note further that the transmission of energy in sonic waves is governed by laws showing remarkable analogies with such laws of electric circuits as the Ohm law, the Joule law, etc.

The Constantinesco principle has been applied for numerous purposes during the war when the inventor was working for the British Admiralty. Among these may be mentioned the hydraulic hammer with the "single-phase" sonic motor; another type of hammer for chipping stone; drills with two-phase asynchronous sonic motors, very powerful for their small size; servo motors for use on aeroplanes; and, what is

of particular interest, a device for oil injection on Diesel engines. This device has been applied by the British Admiralty to a 1,000-hp. Diesel engine and is said to have given entire satisfaction.

Another interesting application of the same principle has been made in connection with bomb throwers capable of hurling a bomb weighing 220 lb. to a distance of close to 5,000 feet, and that without either fire or noise. In this device the energy of a small cordite cartridge is absorbed in the compression of a liquid which restores it by pushing the bomb under constant pressure over the entire length of the gun barrel, which affects the efficiency of the explosion very favorably.

It is stated that experimental work is being carried on to apply the same principle to the power transmission between the engine and propeller of an aeroplane.

The best known application of the Constantinesco principle is in synchronizing the propeller and the machine gun on aeroplanes, extensively used by the Allied armies during the recent war.—J. Herck in *Bulletin Technique du Bureau Veritas*, Vol. 2, No. 4, April, 1920, pp. 69-73.

A POWER RECUPERATING ENGINE.

GEORGES FUNK, writing in *The Automobile Engineer* for April, 1920, pp. 145-153, discusses the design of engines that

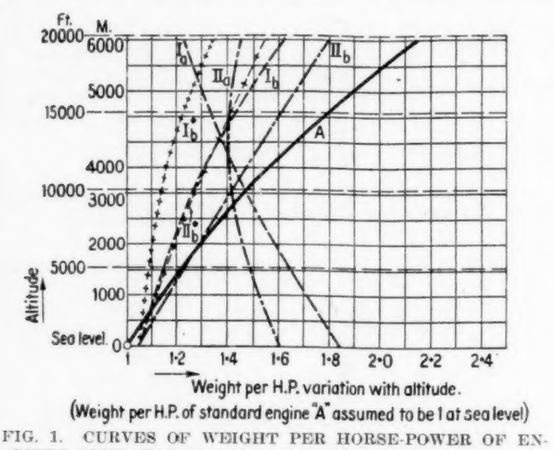


FIG. 1. CURVES OF WEIGHT PER HORSE-POWER OF ENGINES OPERATING ON VARIOUS CYCLES AS COMPARED WITH A STANDARD ENGINE AT SEA LEVEL (A)

would maintain power at altitude with supercharging. The writer discusses the operation of standard engines under various conditions on the basis of their entropy.

The power recuperating engines are classified into two main curves, the first group consisting of those having a cycle of operations such as to maintain a maximum pressure and the group to maintain a constant compression temperature taken into account for both the atmospheric temperature variation.

They may further be divided into certain subdivisions. Thus, case *a* represents an engine designed with a combustion space of such a size that its ratio to the total cylinder volume gives a maximum compression ratio required for the altitude at which the engine has been designed to work.

In order to vary the effective actual compression ratio as required by the altitude, it is proposed to close the inlet valve before the piston reaches the end of the stroke which amounts to having an engine with a variable compression but a constant expansion stroke.

This cycle is really the Atkinson cycle, with the modification that the effective compression ratio is variable with the altitude while the expansion ratio is constant, until at the predetermined altitude the standard cycle is arrived at. In this connection Fig. 1 is of interest as showing that the weight of such an engine per unit output would be quite large at sea level.

The simplest way to perform this cycle mechanically appears to be to provide a variable inlet charge cut-off by altering the timing of the inlet valve, which could be done in several ways; for example, the valves could be operated by means of rockers mounted on eccentric pins as illustrated in Fig. 2.

By rotating on its housing H the eccentric E which carried the swivel pin S, the clearance C between the rocker R and the valve V is altered and the valve lift and duration of opening is modified, thus effecting the inlet charge cut-off.

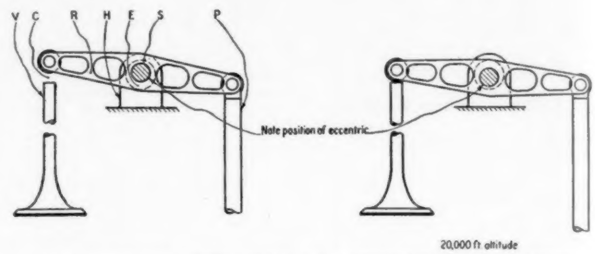


FIG. 2. VALVE OPERATION OF ATKINSON CYCLE POWER RECUPERATING ENGINE

Case *b* represents an engine so designed that the volume of combustion space is adjustable. Attempts to do this were made by introducing the piston in the upper end of the cylinder, so located that its combustion can be modified at will, thereby reducing or enlarging the combustion space. This involves a complicated and inefficient valve gear. Another proposition has been made to make the whole cylinder movable up and down, which is again too complicated for immediate consideration.

The variable stroke method has been proposed. The design of a variable stroke engine of the multi-throw type of crankshaft presents mechanical difficulties. It is, however, comparatively simple in connection with radial engines. Thus, Fig. 3 shows the design of a radial power recuperating engine.

Over the crank pin C is fitted an eccentric sleeve D, which carries the connecting rod A mounted on ball bearings in the usual manner. The eccentric sleeve can be rotated partially round the crank pin and held in any desired position. It is obvious that by this arrangement the stroke of the piston can be altered at will. Only a small eccentricity is required to give the desired result. Even in the extreme case of group 1, to which the curves relate, an eccentricity of 5 per cent of the shortest stroke is all that is necessary to effect power recuperation up to 20,000 feet.

In order to operate this eccentric sleeve from outside, a

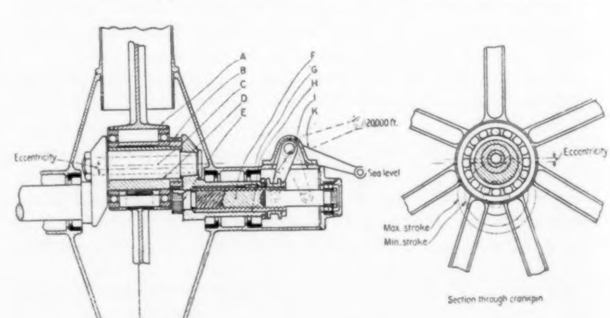


FIG. 3. RADIAL POWER RECUPERATING ENGINE

gear wheel B is attached to the sleeve. Into this gear meshes another wheel E carried on the spindle F, the latter being provided with a multi-start quick thread as shown. A sleeve H with a corresponding internal thread engages the thread of the spindle F. This sleeve is prevented from rotating by one or more keys G lodged in the crankshaft in such a manner that an axial sliding motion can be imparted to the sleeve

H by means of the lever I. It will be seen that by operating the outside lever K, which is coupled direct with lever I, the eccentric sleeve D can be rotated to any desired position, and maintained there while the crank is revolving, modifying the effective throw of the crank and thereby the piston stroke.

As the eccentricity is very small, the reaction of the connecting rods while under load on the eccentric sleeve is small, and no undue force would be required to operate the mechanism while the engine is running. Should there be any difficulty, however, the throttle may be closed for the short period of the change, which would be effected in steps according to the altitude. However, in proportioning the lead of the multi-thread and the levers correctly, this process of operation would hardly be necessary. For the same reason the different positions of the eccentric affect the timing of the engine only to a small degree, and it should be possible to design a case so that a satisfactory timing for all altitudes is arrived at, or such a timing may be evolved which gives the best result at the altitude at which the engine is called upon to run normally.—*The Automobile Engineer*, Vol. 10, No. 137, April, 1920, pp. 145-153.

SHIPYARD CRANE.

A LARGE number of European yards adhere to the ordinary mast and derrick shipyard crane. Invariably the hoisting winch, whether steam or electric, was placed on the ground level with the attendant trouble of having the hoisting rope leading from the winch to the derrick mast always entangled in bars and plates and all sorts of rubbish. This arrangement also necessitated having signal men placed here and there, as the winch operator could not as a rule see what he was doing.

Other yards are equipped with expensive overhead traveling cranes, such as gantry cranes, or with cantilever cranes common to two contiguous berths and running either on rails laid on the ground or on a high gantry erected between the berths. Revolving cranes are also used, either of the high-power type traveling on rails laid on the ground or a small revolving crane running on rails laid on a gantry erected between berths.

The author of the paper investigated the crane arrangements on some two score of plants and found that, on the whole, nobody seemed satisfied with the crane arrangements he possessed, and the cranes not only were not standardized, but it was almost always the case that a different system of cranes were tried at almost every building berth in the same yard and for every new berth laid down.

The conclusions to which the author came as regards the general principles of crane construction are as follows:

1. The mast and derrick arrangement is quite satisfactory, provided it can be so arranged that all side staying of masts can be done away with.

2. The operator's platform should be placed high above the ground on, for instance, the level of the principal weather deck of the ship, so that the operator can see what he is doing, thus obviating the necessity of using signal men.

3. The lead from the hoisting winch to the derrick mast should not be taken along the ground among staging uprights, shoring, plates and bars, and various rubbish strewn about the ship. The lead from the winch should be free from all obstructions.

4. A space or passage-way is desirable between contiguous ships to enable building material to be brought down between ships and hoisted on board from the nearest point at the ship's side, and not from the ship's end only. Such an arrangement covers many more chances of rapid building than an arrangement based, for instance, on the material being taken in hand by the hoisting gear at the end of the ship only, because the former arrangement offers so many more points of attack on the ship than the latter.

Guided by these conclusions he designed the stationary crane shown in Fig. 3. This type is chiefly composed of a stationary main structure and two swinging arms, the former consisting of two lattice-work masts placed about 15 ft. 3 in. apart from center to center, and rigidly connected to one another by cross stays and trusses making the main structure stable in the thwartship direction, thus obviating the necessity of fitting side stays. The author calls such a structure consisting of two derrick masts rigidly connected to one another by cross stays and trusses a derrick frame in contra-distinction to the solitary derrick mast. Each derrick frame carries two derricks or arms A which can swing about 120 deg. to each side of a vertical thwartship plane through the derrick frame, *i.e.*, well past the center line of railway B laid down in the passage-way between contiguous ships. The derrick frame is held in place by fore and aft wire stays only. For this purpose two sets of stays are fitted, the lower ones C partly for giving rigidity to the cranes in a fore and aft direction and partly for preventing collapse of a whole group of interconnected cranes in case the top and stays R, or some of the top stays D, fitted from crane top to crane top of the group should give way.

At a suitable place above the ground two winch platforms E are built into the derrick frame, one above the other. Access to them is given by ladders inside the frame legs E.

Each crane arm and the load are controlled from the platforms E by a single ordinary alternating-current electric

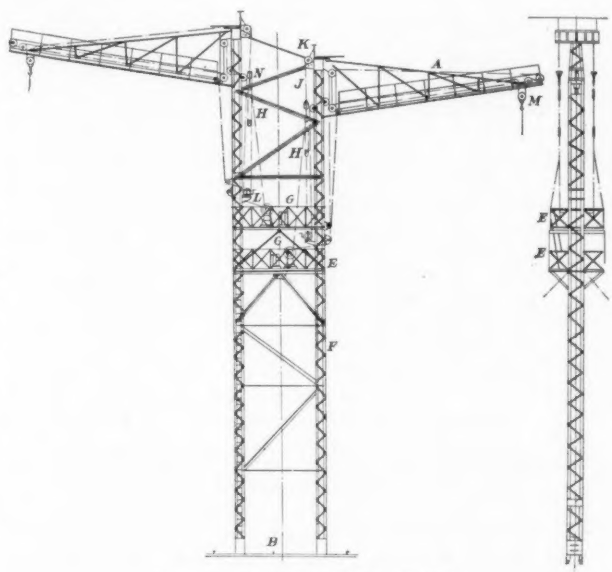


FIG. 4. HOK SHIPYARD CRANE

shipyard winch G, which means that they are controlled by one electric motor only. Hoisting and lowering are done with the winch center barrel in the ordinary way, and slewing with the extended winch ends by taking a couple of turns round the appropriate extended winch end with a loose end of a tackle H, actuating the wire J, which is carried round and fastened to the rim of the horizontal wheel K on top of the crane.

A spiral spring N is introduced above the slewing tackle for the purpose of taking up the inertia of the crane arm when it arrives at the extreme end of the swing, in this way preventing damage and unnecessary straining of the connections in case of rough usage or ignorance on the part of the man handling the crane.

The method of racking motion is described in some detail, as well as the method of erecting these cranes.—Paper read before the Institute of Engineers and Shipbuilders in Scotland, abstracted through *Marine Engineering and Canadian Merchant Service Guild Review*, Vol. 10, No. 4, April, 1920, pp. 84-87.

Progress in Mining and Metallurgy

Abstracts of Papers to be Read at the Fall Meetings of the A. I. M. M. E.

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

FLUE-TYPE COTTRELL TREATER.

By A. B. Young.

This paper describes a Cottrell treater that was placed in operation in April, 1919, at the Tooele plant of the International Smelting Co., to recover solids from the gases from the McDougall roasting furnaces. Fundamentally, the treater is simply a flue containing rows of vertical plates, forming the grounded electrode, alternated with rows of small horizontal pipes, forming the negative electrode, with proper provision underneath for taking away collected dust. There are advantages in construction over the more cumbersome types, both the vertical-tube and the vertical-box, particularly in the elimination of heavy supporting columns and massive foundations, giving a much lower first cost. There are no right-angle turns to interfere with gas distribution, consequently there is greater efficiency; that is, a greater volume of gas per minute can be effectively treated. Another advantage of the horizontal installation over the vertical is that the principle of the selective precipitation of the various components of the dust and fume as they pass along the electric field may be utilized. Since the treater has been placed in operation, the results have been quite satisfactory and, in many ways, particularly in regard to the volume of gas that may be treated, have greatly exceeded expectations.

The outstanding features are the constantly decreasing copper values and increasing lead values as we proceed along the treater toward its discharge end, with the result that a portion of dust collected may be segregated and smelted for its lead content. An examination of the figures for iron and insoluble matter bears out the idea that there is a marked tendency to precipitate the true dust particles near the entrance, and that the more impalpable fumes must travel a greater length through the electric field before being caught.

It is extremely difficult to state, with any degree of accuracy, the power input into the treater, other than that it is much lower than one would expect and is quite variable. For normal gas volumes (125,000 to 150,000 cu. ft. per min.), the input of power will average very closely to 8.4 kva. for the first electrical section and 5.5 kva. for the second. Approximately 85 per cent of the dust caught is collected by the first, and 15 per cent by the second section.

This form of installation has proved admirably adapted to these particular gases. No data are available as to its ability to treat satisfactorily a purely fume product. However, when one compares this compact flue-like building, which is efficiently handling 150,000 cu. ft. of gas per min., with the complex towering structures of the vertical type necessary to treat this amount, one is convinced that a distinct step forward has been taken.

UTILIZATION OF TITANIFEROUS IRON ORE.

By J. A. Heskett.

New Zealand is dependent on the outside world for its ferro products yet it has at least two well-defined iron-ore deposits, the Para Para limonite, and the Taranaki iron-sand, a combined magnetite and ilmenite. This latter deposit forms the greater portion of the beach sands of the west coast of the North Island of New Zealand. To all appearances it is a chemical compound of the double oxides of iron and titanium and not a mechanical mixture.

Knowing the difficulty with which the iron-sand is reduced, the writer conceived the idea that if the reduction were made largely a direct one the chances of reduction would be more complete and the gases would be richer in carbon monoxide, which in turn would give a desired result. By mixing coking coal and fine iron-sand in the proportion of 1 to 1, coke or ferrocoke, that ran 36 per cent metallic iron and 40 per cent carbon was obtained. At the same time a greater portion of the oxide was reduced to a metallic state in the 8 hr. that elapsed in the coking process. This ferrocoke was charged with the limestone into the experimental furnace, which was like a foundry cupola. It was 8 ft. from charging door to tuyeres, 3 ft. in diameter, and was served with four tuyeres with a 6-oz. blast pressure. It was water-jacketed and had water-cooled tuyeres.

After repeated experiments, this process was abandoned because the friable nature of the ferrocoke at an incandescent temperature caused a congestion of finely divided coke, which became entrapped in slag and gradually contracted the working area of the hearth.

Because of the indifferent quality of iron produced by the cold-blast practice a hot stove was installed and the existing furnace heightened. Eventually the U-pipe hot blast was installed and the process was brought more in keeping with modern practice of ore reduction, relying on a greater percentage of indirect reduction. The amount of pig iron produced was 50 tons, averaging 5 tons per day.

The slags were fluid and no trouble was experienced in their handling. In fact, the titanic-acid content would lead one to believe that it had lowered the fusion point as well as the viscosity of the slag. At times the titanic-acid content was brought up to 20 per cent as an experiment, on subsequent trials, and the fluidity was in no way impaired, so the theory of viscid slags due to normally high titanic-acid content might easily be dispelled.

Whether the practice of mixing equal parts of nontitaniferous and titaniferous ores, as practiced at Port Henry, N. Y., is beneficial to foundry practice remains to be seen. Our experience is that the pig iron produced from titaniferous ore will not grain out as will other iron of similar analysis. It has a ready tendency to chill even in ordinary sand casting with 2.5 per cent silicon and 0.04 per cent sulfur. This chill is only to a depth of 1/32 in. The iron is exceptionally strong and tough, easily standing 25 per cent greater breaking strain and deflection. Castings made from this iron have a wonderful finish, surpassed by no other iron used in the writer's foundry experience. Where extreme softness is required in thin castings some founders object to this iron. It is more adapted to steel production than every-day foundry iron, and the steel produced has exceptional strength, ductility, and malleability.

NEW METHOD OF MAKING FIFTEEN PER CENT PHOSPHOR-COPPER.

By P. E. Demmler.

Phosphorus combines with copper in various proportions, forming true alloys, some of commercial importance, which find wide application as deoxidizers and as a means of introducing phosphorus into other alloys, as in phosphor-bronze. Phosphor-coppers containing 10 and 15 per cent phosphorus are the commercial grades most generally offered.

Processes for making phosphor-copper may be divided into two classes: (1) Those depending on the smelting of phosphate rock or superphosphate of calcium with copper or copper-

bearing materials, and coal or other carbonaceous material; (2) those depending on the direct combination of metallic copper and elemental phosphorus.

Among the objections to the first method of producing phosphor-copper are the large amounts of raw material and resulting slag to be handled, and the difficulty of getting a satisfactory fusion.

Methods of the second class are generally used. The usual practice is to add the phosphorus to the molten copper by means of phosphorizers. This method entails a phosphorus loss of at least 25 per cent, and there is danger of burns to the workmen. Various methods have been suggested for obviating these objections.

Experiments of the author have shown that a uniform 15 per cent phosphor-copper could be produced by passing phosphorus vapor over heated copper. The most satisfactory temperature of the copper was found to be 400°C. Phosphorus boils at approximately 290°C and when this vapor passes over heated copper, combination takes place immediately with incandescence and incipient fusion. Pieces of copper wire up to ¼ in. in diameter are completely phosphorized by this method.

An apparatus having a capacity of about 130 lb. of phosphor-copper was constructed to demonstrate the commercial value of this method. This apparatus consists of a retort for heating and distilling the phosphorus, a container for the copper, and fittings to connect the two. Suitable supports are also provided. The apparatus is made entirely of iron, which is not attacked by phosphorus at the temperature of the operation. Means are provided for heating the phosphorus and copper separately.

To operate, phosphorus is placed in the retort, clean copper scrap (such as wire, turnings or millings) is placed in the copper container, and the two are connected. Tight joints should be made by using suitable gaskets to prevent loss of phosphorus. A hole drilled into the plate covering the end of the copper container prevents increase of pressure within the apparatus. The copper is heated to 400°C. before heat is applied to the phosphorus. With the small apparatus phosphorus has been distilled at the rate of 30 lb. per hour.

Phosphorization to 15 per cent phosphor-copper takes place in one step, no intermediate products being formed if conditions as to temperature are observed.

The method of making 15 per cent phosphor-copper, outlined above, had the following marked advantages: The copper need not be heated over 400°C,; the phosphorus need not be handled near hot or molten metal; there is no loss of phosphorus; and the product is uniformly 15 per cent phosphor-copper.

CARE OF ROCK DRILLS.

By Howard R. Drullard.

To OBTAIN the best results from hammer drills, close attention must be paid to lubrication and the shank. With the exception of stoping drills, most modern rock drills require both oil and grease. Ordinary machine oil is not adapted to rock drills; a heavier more gelatinous oil, such as castor machine oil or liquid grease, should be used. Hard grease must not be put into the lubricators, as it will not flow through that part. Contrary to the popular belief, oiling a machine once or twice a shift is not sufficient; the drills should be oiled once for every 12 or 14 ft. of hole drilled. Stoping drills require oil at least twice a shift; lighter oils than castor, such as Arctic Ammonia, may be used.

Drills used in shaft sinking can be oiled satisfactorily by placing a good-sized, drop, sight lubricator on the station above the sinking operations and connecting it with the airline supplying the sinking drills. If the lubricator is properly filled and adjusted, a uniform oiling will be effected without oiling the drills individually. The grease end should be filled at the station or surface before each drilling period. The shift boss should see to it that the machines are greased and also that the lubricators at the station function properly. The life of the air-drill hose is somewhat shortened by this method, as oil attacks the inner tube, but as some oil is always present in the compressed air, this is not a serious objection.

DRILL SHANKS.

The method of forming drill shanks on a standard drill sharpener is simple and quite generally understood. The shanks, however, must be accurately made and maintained to the dimensions; a variance of ¼ in. in length will often reduce the drilling speed of the machine 25 per cent.

Close attention must also be paid to the shape and location of the hole made to accommodate the water tube. To avoid excessive breakage of water tubes, this hole must be 5/16 in. in diameter and punched to a depth of at least 3 in. It must be in the center of the steel, and after punching should be counterpunched slightly to prevent formation of a sharp edge that will cut off the water tube. The shank, of course, should present a smooth striking face.

The shank when properly formed is hardened. The operation is simple, involves no delicate judgment of temperatures or high mechanical skill, can be learned by any intelligent blacksmith in a few moments, and gives a shank so hardened that it will not batter, break, or damage the piston hammers of the rock drills.

The proper treatment of the shank begins in the forging. The steel must not be overheated; that is, it must not approach a white heat. The steel must not be allowed to "soak" in the fire, as this causes scaling; an unduly high air pressure in blowing the forge will also cause the steel to scale, and a scaled shank will not respond properly to the hardening process. After forming, the shanks should be annealed by being cooled gradually; preferably, they should be covered with lime or ashes and allowed to cool.

Either fish or linseed oil is satisfactory for hardening, although other light oils are at times used. The quantity required is proportionate to the number of shanks to be hardened at one time. Five gallons will suffice for the hardening of three or four shanks, but if considerable steel is being worked, 45 or 50 gal. are advisable. A rectangular tank in which the steel can be stood up conveniently is generally used. The oil must be kept free from any foreign matter, particularly water.

The shank should be heated to a cherry red at the striking end with the heat graduated to a dull red just beyond the collars, or lugs; or, in the case of the shankless stoping steel, to a point about 4 in. from the end. The shank is then plunged into the oil and allowed to cool thoroughly.

Each and every shank must be so hardened that it can be readily cut with a file. The shanks must be softer than the piston hammers or damage to both will result.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

MERCURY ARC RECTIFIERS

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

THE abstract "Mercury Arc Rectifiers for Large Outputs," appearing in SCIENTIFIC AMERICAN MONTHLY, 1920, Vol. 1, No. 3, page 279, contains the following statement:

"The favorable results obtainable with apparatus of low output encouraged the Société Anonyme, Brown, Boveri & Co. to investigate the question of building rectifiers for large outputs.

"A rectifier company was formed by the firm in 1912 in Glaris (Switzerland) for the purpose of carrying out the necessary experimental work and the technical staff of this company soon made the acquaintance of numerous difficulties of a practical nature."

The writer may be permitted to point out that this statement is not correct.

The Brown-Boveri rectifier was not developed by mentioned firm nor by the rectifier company in Glaris (Switzerland), but by the firm Hartmann & Braun, located at Frankfurt (Germany), where the large capacity rectifier system Schaefer was developed (compare *Electrotechnische Zeitschrift*, page 2, 1911). In 1913 Brown-Boveri took over the patents of Hartmann & Braun respectively. Schaefer and the technical staff responsible for this design entered the firm of Brown-Boveri in Baden (Switzerland), partly as directors.

At this occasion it may be stated that it was the writer who took up first rectifier work in Switzerland by making an extensive experimental and theoretical investigation[1] on the mercury arc rectifier (Cooper Hewitt rectifier). Incidentally, the writer invented a basic principle[2] especially fitted for mercury arc rectifiers of tremendous capacity. (Compare *Schweizerische Bauzeitung* No. 13, 1920, page 147.) As the original Cooper Hewitt patent still controlled the Brown-Boveri respectively Hartmann-Braun Schaefer patents the mentioned firm was dependent upon the Cooper Hewitt, respectively Westinghouse firm.

The article, "Mercury Arc Rectifiers for Large Outputs" contains also the following statement:

"The losses in the mercury arc rectifier are equal to the product of the current and the pressure drop across the arc, etc. The losses, therefore, for a given working pressure are equal to the load current multiplied by a constant, this constant being the voltage drop across the arc so that the efficiency of the rectifier is the same for all values at all loads."

The writer having made extensive investigations on this subject[3] can only state that this statement is clearly erroneous. In the mentioned articles the writer has clearly shown how all the losses in a rectifier can be determined and it would be highly desirable that such unreliable statements as mentioned above would disappear from the technical literature.

WM. TSCHUDY.

Yonkers, N. Y.

[1]Experimentelle Untersuchungen am Aueck silber dampfgleichrichter für Wechselstrom. Thesis Federal Technical University Zürich, 1912.
Bulletin des schweizerischen Elektrotechnischen Vereins, 1912. Uber die Entwicklungsmöglichkeiten des Quecksilberdampfgleichrichters auf grund experimenteller Untersuchungen.
Zeitschrift für elektrische Kraftbetriebe und Bahnen, 1913.

[2]German patent No. 255547, American patent No. 1189887 reissue No. 14816.

[3]See former mentioned articles.
Electrical World, 1916.
Elektrotechnische Zeitschrift, 1917.
Electrical World, 1918.
Schweizerische Bauzeitung, 1920, p. 147.

"STANDARDS FOR SCREW THREADS."

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

The article in February issue entitled "Standards for Screw Threads" has been read with considerable interest, and the writer commends its clearness and hopes it will be widely read. Its appearance at this time is a very good education for the general public, because the proposed standard of the National Screw Thread Commission, appointed by act of Congress, will be issued very shortly, and the terminology in above mentioned article agrees with that of the National Screw Thread Commission's report.

The cuts and description of threads and the fit of mating parts are clearly shown in your article and a little analysis of these would show why any trouble exists in making proper fits from a theoretical standpoint.

Theoretically, there is nothing mysterious about a thread fit—it is simply the number of factors involved. A good cylindrical fit depends on the size, rotundity and parallelism of the mating surfaces. A good sliding fit (rectangular or otherwise) depends on the size, parallelism, and contour of the mating surfaces. A good thread fit depends upon size, rotundity, parallelism, lead and contour of the mating surfaces. Fulfilling these requirements practically becomes more difficult in proportion to the number of factors involved. The important factor in all tight fits and the one thing that the average mechanic entirely loses sight of is the "flow of the metal," due to the plastic nature of the metal.

The writer believes it is a fundamental fact that force fits cannot be made between mating parts unless there is either elasticity or flow of the metal.

Take a ring and plug gage which are correct and the plug can be passed freely through the ring by a skillful man. Cover the mating surfaces with oil, and it requires force to get the plug through, the same will be true if the plug were, say, ½ thousandth of an inch larger. Careful measurements will disclose that the ring has expanded or stretched, and the tightness of fit is due to the tension of the metal in the ring or its elasticity. If the ring were made so large it could neither expand nor the metal compress, and a hardened plug were driven in, the plug would be longer after being driven in because it "drew" out in length, thus being easier than moving the metal of the large ring. It will be found nearly impossible to force a fit unless the metal of one or both moves.

This flow of metal is a phenomenon taken advantage of by many artisans, but seems to be lost sight of in thread fits. The accurate production of all the factors involved in a good thread fit is practically impossible, and even in the best of gage work small tolerances are permitted to avoid prohibitive cost so that even these precision gages do not exactly fit. When this condition is realized, it must be evident that commercial screw thread product is far from this accuracy, yet must go together to function properly. It does this in all fits except the loose ones, because the metal flows and the crest and root clearance is a space provided for the excess metal, due to both contour and lead, to flow into.

All tight nuts, if forced on several time with oil on the mating surfaces, will approach an apparent good fit, that is, the metal will flow so that the mating surfaces conform to each other, and it answers the purpose if not too badly off.

This feature permits interchangeability of close fits, and if it were not so, there would be but a limited interchangeability in this class of work.

The article in the February issue mentions the various systems of threads in use, and these are not all, as the records of the United States Army, Ordnance Dept., will substantiate. The writer, while in charge of the Gage Section of the Ordnance Department during the recent world war, had to contend with fifteen distinct thread systems and gage up Ordnance material made to all of them. He was Chairman of the National Screw Thread Commission on its trip abroad, studied the question of an international standard at close range, and offers the following observations:

(1) Is an International Standard for screw threads desirable?

(2) What is the best system in use?

(3) Which would give the least trouble to universally adopt?

It would seem that the answers to these would pretty nearly solve the problem so far as America was concerned, and an affirmative answer to number one will hardly be contested.

Regarding number two, those who have had extensive experience in threads of all kinds will unhesitatingly say the "American," meaning thereby the United States Standard for coarse pitches, the S. A. E. standard for fine pitches, and the A. S. M. E. for screws smaller than the first two provide for, is the best.

All things considered, the 60 degree thread is the best and easiest to produce and verify.

The truncation of the triangle to ⅛ of the pitch is satisfactory for both making and functioning. In fact, it is so satisfactory for all purposes that it is as well known and as much used in Canada as in the United States. This in itself speaks wonders for it, as Canada naturally inherited to some extent the Whitworth system from her Mother Country and supplanted it with that of a neighbor. When Canada got to making munitions for Great Britain with Whitworth threads, there was considerable trouble and they could not understand why anyone could stick to such a system when there was one so easy to make in comparison.

The French, when trying to standardize, adopted the 60 degree thread flatted top and bottom to ⅛ of the pitch, thereby concurring in its merit.

The answer to number three is best stated by saying that conferences in England developed the fact that 70 per cent of the screw thread product of the world was made to inch measurements. 55 per cent of the world's screw thread product was made to the American standard, while 15 per cent was Whitworth. All other systems, including the metric threads, made up the balance, or 30 per cent.

Therefore, one-half of the screw thread product of the world does not need changing if the American standard is adopted. Saying it another way, if any other system became the standard, this 50 per cent and either the 15 per cent or the 30 per cent additional would have to be changed to suit a very small minority.

What is more important, there is easily three times as much screw thread product in stock made to American standards as all the rest put together, and it would be nothing short of a crime to try to force any other system into use which would sacrifice this stock. It is believed that the Standards proposed by the National Screw Thread Commission will enable practically all the American threads to be used and for all loose and medium fits, those of the Whitworth system as well, excepting one size and pitch.

If England set the tolerance on the angle towards 60 degrees and America set it towards 55 degrees, the majority of work will go together and function properly, as the rounded crest and root play no part in the fit and a space is provided for it.

The only other system in enough use to mention as a possibility, is the French Internationale, and all it has to recommend it is the 60 degree thread with ⅛ of the pitch flattened. The diameters and pitches do not conform to anything else in the world and could never interchange with the American threads.

The fundamental basis of the system of pitches is built upon an ideal which is impracticable, viz.: the pitch is in millimeters from the center of one thread to the center of the next, and six to ten times this pitch is the diameter of the screw. This offers no advantage and many mechanics think it has a good many drawbacks.

The National Screw Thread Commission suggested to the French Commission that there might be a reconcilliation of pitches if a new unit of length is named which would have the value of 5 inches and 127 m/m. Then by multiplying the present American and English pitches by five and calling it the pitch in turns per the new unit of length, it offered a means of interchangeability if the French would make their pitches the same number of turns per 127 m/m, which, of course, means they would be identical. The French diameters would then become fractional millimeter sizes to interchange with American and English standards. It was pointed out that this would be the least hardship because of the great amount of screw thread product in stock in America and England.

E. C. PECK,
Vice-Chairman, Nat'l. Screw Thread Comm'n.
(Formerly Lieut.-Col. Ord. Dept.)

Cleveland, Ohio.

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